American Machinist

Volume 65 New York, July 1, 1926 Number 1

Emphatically Yes

Is the answer of the National Cash Register Company to the question

Do We Believe in Foremen Training?

By Wm. Hartman
Superintendent, National Cash Register Co.

FOREMEN hold a strategic position in industry. Let this position be properly appreciated by management. Let the foremen be given the opportunity to gain the knowledge needed in handling their jobs. Then most of today's in-the-plant waste will be eliminated; there will be far fewer difficulties between management and men; and management will be justified in holding foremen fully accountable.

It has always, more or less, been the custom of the National Cash Register Co. to hold meetings of foremen and executives for the purpose of discussing problems that affected production and the management of the business. The meetings were held at regular intervals. Many times foremen were criticised for their methods of production or the handling of men. Some times these criticisms were just and sometimes unjust, with the result that it was not unusual for the men to come to the meetings with more or less fear, and hesitant about openly taking part. There was no systematic plan of foremanship training, with the result that there was not a progressive development of these men.

An Organization of Foremen

From such beginnings grew our present organized system of foreman training. In placing the plan before the supervisors (division heads) and asking for their support, it was pointed out that we had been securing the men to be leaders on a trust-to-luck basis. They were taken from the ranks, made foremen, and held to responsibility, without constructive assistance except such as was obtained in a negative way from our unorganized meetings. It was proposed that we have an organization of foremen, to study the problems of foremen. No job foremen were to be included, so that there would be no possibility of a foreman's being embarrassed before his subordinates, either by being shown to have erred, or by being asked to state his views in their presence. The idea was to have a class of men of equal positions, with the hope that there would be a feeling of freedom.

The plan was supported by the supervisors and accepted by the foremen. One hour per week of company time was allotted for the classes and the meetings were immediately begun under the direction of the superintendent. The beginning was in kindergarten fashion. The first aim was to bring up the calibre of the foreman, to make him appreciate the importance of the position of foreman and its limitations. We criticised the handling of men, bringing out good and bad methods; pointed out the causes of and the remedies for friction between departments; and discussed similar subjects. What we wanted to do was to present certain fundamentals and get the foremen to discuss them. Perhaps above all we wanted to get over the idea of tact—what tact is, and how much it means as a constructive tool. Here are some of the subjects discussed.

Health	Willingness to accept suggestions and recommendations
Habits	Co-operation and adaptability
Personality	System (being systematic)
Knowledge of position and product	Ambition and enthusiasm
Leader and teacher	Service
Honesty and square dealing	The value of a thorough self-analysis
Observation	Hiring an employee
Resourcefulness	Foreman's interview
Tact and diplomacy	Starting an employee
Decision— not snap judgment	Discharging an employee
Investigation	Rating employees
Imagination	Qualifications of the 100 per cent foreman
Initiative and inventive ability	Modern wage-payment methods

These subjects were assigned the different foremen, who presented the various phases of the subject in bulletin form.

The first reaction was a marked interest on the part of the foremen. Whereas formerly they had been decidedly silent, under the new arrangement they did not hesitate to express their views. Many times several were on their feet at once. They discussed the subjects among themselves, out of meeting hours, and asked for

the subjects in advance. They learned to make notes as prompters and not to rely entirely upon memory in speaking.

Then, with an understanding of tact established, we began on our practical shop work. The classes are now so far advanced that we are working on the following topics, under the heading, "Improvements Needed During 1926":

1. The elimination of waste
2. The elimination of inferior workers
3. The replacing of obsolete or worn out machinery
4. Standardization of product and improvement in design
5. Improvement in, and standardization of, materials and methods

In offering these subjects the suggestion is made to the foremen that the objectives can be obtained by means of a systematic study of:

1. Costs
2. Present methods, design, organization, and equipment
3. Trade papers

For study, the subjects enumerated will be split. The elimination of waste, for example, will be sub-divided extensively. Each foreman will comb his department thoroughly to find material for presentation at the meetings. Much unusual and unexpected information will be brought to light. The foremen will be individual and original in their work, will really lead instead of follow. The old idea, that men and foremen were only to follow orders without knowing why has been responsible for tremendous loss in industry. If we want to get the most out of any worker, be he executive or bench hand, the more information he has the more he will do, the better he will do it, and the easier he will do it.

Objects of Foreman Training

Our objects in foreman training are set forth in the following letter that I wrote E. W. McCullough, manager of the department of manufacture of the U. S. Chamber of Commerce:

"We have been conducting a course in foreman training for a number of years. The general plan is to meet once a week for one hour on the company's time. The school is limited to foremen; job foremen are not eligible.

"There is no set rule for conducting these meetings but generally a member is assigned a subject about a week ahead and told to present it at the next meeting. This school is conducted by the company itself under the direction of the superintendent.

"From a practical standpoint we find that the training of foremen has resulted in securing greater efficiency through more intelligent application and with a greater degree of personal pleasure in working out the various tasks and plans that are met in the operation of an industrial plant.

"The first reaction was shown in the direction of greater co-operation, a desire to become more fully informed on the problems that are met by an executive, the reading of up-to-date works on factory management, and a study of fundamentals of systems, methods, machinery, and employees.

"The weekly meetings make it possible for the foremen to train themselves in self-confidence through the exchange of experiences and to express themselves in public on their feet. The various subjects which were assigned to the foremen made it necessary for them to thoroughly investigate and hence greatly increase their knowledge, the effect being that the greatest benefit was secured by those selected to present the subject. Men who formerly were lacking in tact, observation, initiative, application, co-operation, and thoroughness, show a marked improvement.

"It has been our aim to select those subjects and to conduct the meetings in a way that will give the foremen a greater outlook, increase their sum of general knowledge as affecting industry as a whole, and in our production in particular, so that they will be equipped to intelligently meet outside executives and representatives and give a good account of themselves, and also have those fundamentals that would be of great advantage in securing executive positions with other industrial plants."

One unlooked for result of our foremen training classes was that our job foremen solicited the educational department to inaugurate foremen training classes at night. The classes, now in operation for two years, have been among the most regularly attended and have more full-course students than any other night classes. Registration and attendance are voluntary.

After our foremen training course had been in operation for some time the foremen were asked to comment relative to the benefits derived by attending the meetings. Some of the comments, selected because they are typical, are quoted here. They were in no way stimulated or influenced by management, except as the men may have been influenced by their complete understanding of the company's policy always to have the truth, and its endorsement of free speech:

Department "A"

Some of the benefits that I gained from the foremen's school were:

1. Helped me to understand more fully the duty I owed the company and myself.
2. To be prepared.
3. Showed me some of my failings and helped me to correct them.
4. Gave me the courage to get on my feet and talk.

Department "B"

These meetings are helpful in many ways, but the chief good derived, at least as far as I can see, is the better understanding of our various kinds of work, our common troubles, etc., and last, but not least, an improved understanding of each other's disposition and general mental make-up. The result of all this is co-operation and the end of the friction now so noticeable by its absence.

Department "C"

It has given me a broad understanding as to the policies of this company and how to adhere to them. It also increased my knowledge of these subjects, thus giving me a broader view into the necessary co-operation and has benefited me in my work when the subjects referred to have been brought up in my daily work. I also feel that as this knowledge of the policies laid down by the company has been taken up in a general way by all foremen, I am better fitted at this time to justly co-operate with all workers in this plant that I may come in contact with.

DEPARTMENT "D"

The following are reasons I think the foremen's meetings have been valuable:

1. Have developed a closer and more prompt co-operation between departments by carrying out the idea, "If you want the other fellow's co-operation, co-operate with him always."

2. Have brought out stronger than ever how necessary it is to have a frequent self-analysis.

3. Absolute necessity for having a system to everything you do; also having a definite goal and always working toward that goal.

4. You get results quicker by having men together, expressing their ideas as well as imparting instructions you want carried out.

5. Develops more confidence in foremen to express their views from the floor.

6. Broadens foreman's views of the other fellow's problems.

7. Have brought out how vital it is to investigate jobs from all angles before recommendations are made.

8. The other fellow's problems are your problems.

9. The necessity of studying and knowing your man so that questions that rise can be handled with least possible friction.

10. The necessity of studying the successful man to find out what has made him successful.

11. That it is absolutely necessary to be dependable at all times to make progress.

DEPARTMENT "E"

The Friday morning meetings give me more enthusiasm for my work. After returning from a meeting I am always ready to tackle my old problems or hunt for new ones to tackle. They give me an ideal to strive for.

DEPARTMENT "F"

It convinced me thoroughly that the men I am working for and with, are heart and soul in the game, that everyone views his job as his business to improve, enlarge and defend as he would his own place of business, and that everyone has a job to do, not one to hold.

Am also convinced that whatever lack of co-operation I may have experienced in the past was due to a lack of the proper understanding of the other fellow's problems. I have learned that corrections diplomatically made are not accompanied by any embarrassment, which very often is the first stumbling block to co-operation.

The size of our jobs was forcibly brought home to us as well as the necessity of using strictly business methods in conducting our work.

Every subject in the list of lessons for our discussions carried a number of points that I can apply directly to myself, but since results can only be measured by the things that stick, it will be strictly up to me to demonstrate, and this I will try to do.

DEPARTMENT "G"

I can say that each and every one of the different lessons, both individually and collectively, has been very valuable to myself, the job foremen, and the entire department, and all have profited by them for the following reasons:

1. The importance of each one of these subjects toward successful management was more forcibly impressed upon us all.

2. The different subjects forced me to devote considerably more time seeking knowledge from literature related to these subjects.

3. It made me stronger in handling many different problems.

4. It caused me to check myself on all these subjects and so strengthen my weak points.

5. It has assisted me in paving the way for building and strengthening my job foremen on these necessary points of qualifications by giving them the benefit of what we receive at the meetings.

6. It has assisted me in carrying both my personal and business responsibilities.

7. It has helped to take the "chills out of my knees" by making me self-confident.

DEPARTMENT "H"

The foremen's school has helped me to test or judge myself in my ambition to be a successful foreman, and has greatly helped me in developing my good and overcoming my weak points, for I do want to measure up to the standard we are setting in our school for a successful foreman.

DEPARTMENT "I"

To me personally, I feel I learned and profited the most from "Hiring and Discharging an Employee." This subject was especially instructive and just along the lines that I felt my weakness.

DEPARTMENT "J"

The foremen's meetings have brought home to me the importance of considering a question from all angles before making a decision.

DEPARTMENT "K"

When the list of qualifications of a good foreman was issued, I prepared myself for fifteen, probably good, but very uninteresting lectures. How different it has all been. Each subject has been handled in a very interesting and instructive manner; interesting, because we were doing it ourselves, and instructive because to be posted on the subject it was necessary for each of us to study and think. Then we profited by our own and others' mistakes.

A number of us have developed the ability to think along more different lines than heretofore. We were in a rut and did not know it.

I can honestly say that I have advanced more in personal efficiency since the foremen's school was started than in any similar period in my life.

DEPARTMENT "L"

These meetings have helped me personally, mainly because handicaps and advantages in factory management have been freely and openly discussed and applied to the extent that I feel better qualified in my position as foreman of our organization than at any time during the past twelve years that I have served the company as a foreman.

In a town or city where there are several industries, or several plants of one industry, there is a further opportunity for foremen training—the foremen's club. There is such a club in Dayton. It has more than 1,500 members, representing more than 200 plants. The ob-

ject is to raise the standard of foremanship by improving the foreman himself, because the higher the type of its foremen, the more assured is the success of an organization. Thus will the foreman be placed on a higher plane in the estimation of executives.

Through the foremen's club the foremen receive the benefits from the interchange of ideas because of their association with the foremen of other industries. They are improved by social intercourse. They are given opportunities, by inspection trips, to know the other industries in their city, a type of information that is meagre in most localities, yet that is of immense value. I have been called upon by other local industries many times for help, information, and an opportunity to see how we do things, as a result of foremen's club contacts. And, of course, the foremen's club paves the way for the industrial community to capitalize all the knowledge it has, and for the foremen to capitalize their knowledge.

To summarize my statements, I am strongly partisan to foremen training. It is my opinion that management, by which I mean the owners of businesses, should accept the idea wholeheartedly. It should not be their responsibility to finance the courses, except as they provide the time for the classes, and I think it is important that the classes be held on company time. There should be no paternalistic attitude, because of its retarding influence upon self-reliance. Before undertaking the study of specific problems of the shop the foremen should study men—the men who work for them, their fellow foremen, and themselves. Tact, co-operation, leadership, honesty, fairness, suspended judgment, must enter into a successful course of foremen training.

A Production Hindrance and a Remedy—Discussion

By John R. Godfrey

MY old friend Entropy, on page 585, Vol. 64, tells of a condition that exists in too many shops both large and small. It is an unpleasant situation and one that has much to do with the lack of loyalty in many places. For how can we expect a man to be loyal when he knows that, although the boss preaches no cutting of piece rates, they are cut on various pretexts when a man earns much more than the day rate?

I knew one old veteran of a manager who used to speak a lot at meetings of managers, etc., and always boasted that his shop never cut a piece rate. One day, the manager of another shop, nearly a thousand miles away, came to see how he did it—or didn't do it! The old man passed the buck to his production man who had to tell him the truth, and the visitor was peeved to think he had made a two thousand mile trip to find the same method he was himself using, against his will.

I believe that most managers want to play fair, but it's quite a strain on human nature to see a man earning very much above the day rate. That was why the Halsey premium plan got by so well—the manager could see, and show his directors, that half of the saving came back to the company. And it isn't easy to make a director see how much double production decreases overhead and saves in preventing the need of expansion. All he sees is the extra dollars per day on the pay roll.

A few shop managers have the nerve to set a rate, after careful study of course, and stick to it for a given period, no matter how much the man makes. At the end of the year the rate is revised, if the mental strain has been too great to bear.

I can't help believing that piece rates or bonuses ought to be a sort of mutual arrangement. If we wait until we've tested them for months as Entropy suggests, both sides are losing by the delay. I know one shop where the men O.K. the piece rate and where rates are adjusted, up or down, by mutual consent. Sounds fishy, I'll admit, but it was working the last I knew of it. And here is an almost unbelievable example as told me by the manager.

Bill was the best Gisholt man in the place. One of these phenomena who might not have made his salt on some jobs, but who knew Gisholt, frontwards and backwards. They agreed on what seemed to be fair as a rate for a new job, and Bill started in to clean up big. Though his wages were sometimes scandalous, he was cutting costs so much that the manager didn't kick. But some of the other men did. Called it favoritism, and went to the office demanding that they get more, or Bill get less. Bill, peeved by the other men, threatened to quit if they cut his rate, and the manager naturally didn't want to lose him. So he called him in the office the next morning and talked something like this:

"Bill," he said, "the boys are kicking at your making so much money. We don't mind, as we know a large part of it is because you are the fastest Gisholt man in seven counties, and you ought to earn more than they do. But we don't want the other men to quit—neither do we want to lose you. Now what would you do if you had my job?

"I'm not going to cut your rate, since we agreed to it. But you know that when we find a rate too low we raise it. We evidently both made a mistake on that rate. You didn't expect to be able to knock that work out so fast, I'm sure. So we're going to leave it to you to set a fair rate on that job. Go home and think it over. A little vacation will do you good. Come in tomorrow and tell me what you think the rate ought to be."

And Bill calmed down, went home, and the next morning came in and named a new rate that was a trifle lower than the manager had in mind. If Bill hadn't felt that he'd always had a square deal, and that the manager was "a fair minded guy," he'd have quit—since men were in demand, and any shop in town would have been glad to get him.

Confidence and understanding will iron out piece difficulties and increase both production and earnings. The greatest stumbling block, is the manager or foreman who thinks, as Entropy said, "that $4 a day is enough for any girl to make." He is a liability in any business and the sooner any business has a manager who can think in terms of 1926, the sooner it will start paying dividends.

"Slush" casting is the method used to obtain a thin shell of soft metal without the use of cores. Aluminum or other soft alloys are poured into a mold and the metal immediately poured out again. The metal next to the mold, which is generally of cast iron, hardens and does not run out. The thickness can be regulated somewhat by watching the temperature of the metal and of the mold. The wall can be made thicker by repeating the process.

The Screw Conveyor and Its Manufacture

By D. C. Wright

Manufacturing the conveyor backbone—Shrinking collars and pipes—Drilling and slotting the collared ends—Assembling sectional and continuous flight conveyors

ANY reference to the processes incidental to the preparation of those portions of a screw conveyor other than the flights themselves has so far been avoided. The flight itself is the distinguishing part of the various types of conveyors and its preparation constitutes not only a necessary part in the completion of each type but quite frequently involves considerable preliminary planning.

At the same time, the other portions of the conveyor which constitute the "backbone" undergo sometimes many operations and must be kept in mind during the production of flights. The backbones for screw conveyors can be of as many varieties as the flights themselves, depending, as in the case of the latter, very largely upon the use to which the conveyor is to be put, the design of the equipment into which they are to fit and the approved practice in the particular arrangement specified.

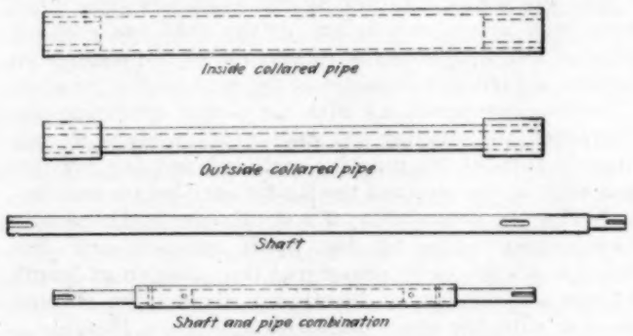


Fig. 16—Types of conveyor "backbones"

Generally speaking, the backbone of the conveyor is either a pipe or a shaft, with occasional combinations of both as illustrated in Fig. 16. Where the shaft alone is used its preparation consists merely of the standard machine shop operations such as the turning of bearings, keyseating for fitted attachments, drilling for pins or lugs or otherwise shaping in conformity with such drawings as may be furnished.

When, however, as is the most common practice, the conveyor is to be mounted on a pipe, the operations become somewhat more involved. A typical set of operations in the latter case includes:

1. Cut-off
2. Collaring
3. Facing
4. Drilling
5. Slotting (where required).

Here again the common practice varies as between the sectional type of conveyor and the continuous flight. The continuous flight conveyor is usually mounted on a pipe with a collar inside of the pipe itself, while the sectional conveyor utilizes a pipe with an outside collar.

At this point it might be well to say that as a matter of economy the practice in screw conveyor design has been to build the various sizes around standard or commercial sizes of pipe, as much as possible. This practice, while obviously economical and proper, has necessitated the specification and purchase of certain odd or special sizes of pipe such as would fit snugly outside or inside of the standard pipe, as the case may be, to act as reinforcement at the ends.

The endeavor, of course, is to not only provide reinforcing at the ends of the pipe against the torsional strains of driving but to obtain a final size of inside hole or bore in the pipe such as will fit a coupling shaft of a diameter that will run well in the size of bearing found in ordinary commercial practice. The couplings between two conveyor sections, which are illustrated in Fig. 17, act as bearings in hangers attached to the box or trough.

Here again, the outside engineer and specification man not infrequently adds many dollars to the cost of the job by insisting upon the use of sizes which, while not uncommon in other lines, nevertheless, do not lend themselves to this combination of requirements and, therefore, involve expensive boring and turning operations in order to provide and fit reinforcing collars.

The first operation in preparing the backbone of the conveyor, where it is to be made of piping, is the cutting of the pipe to length, an allowance of approximately $\frac{1}{8}$ in. being made on an end in the case of piping requiring inside collars in order to provide against upset and inequalities. Collars are produced in standard cut-off machines or in a power hack saw equipped with an automatic feed.

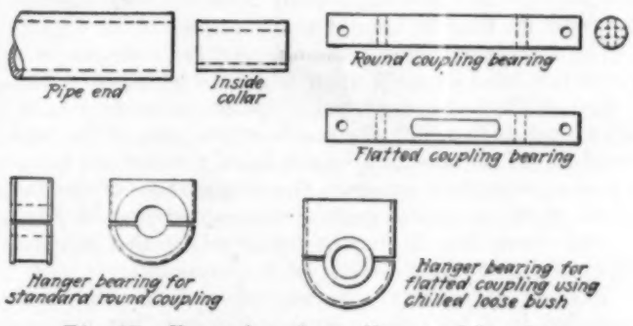

Pipe end
Inside collar
Round coupling bearing
Flatted coupling bearing
Hanger bearing for standard round coupling
Hanger bearing for flatted coupling using chilled loose bush

Fig. 17—Examples of couplings and bearings

In many cases, these collars, being made from welded

The conclusion of the article.

pipe, are either slightly out of round or possess a distinct rib along one side at the line of the weld. It is then necessary to size them so that they will fit properly on the coupling plug. The sizing can be done in a number of ways, depending on the circumstances. The sizing may be done by means of the simple and crude process of using a drift and hammer or the drifting can be done mechanically in a crude rig attached to a bulldozer or some sort of reciprocating press.

Since one of the principal aims of the collaring operation is to secure a tight fit between the collar and the pipe end, it follows that in the case of an inside collar, the pipe end itself is heated and in the case of an outside collar, the collar itself is heated to secure the effect of shrinkage against the inner part. An inspection for straightness must be made after the collaring operation, since a comparatively slight distortion at any point in a conveyor section 8 ft. or more in length would cause considerable wabbling when the piece is mounted on bearings at each end. This wabbling might easily cause the conveyor to drag and it is necessary that reasonable care be exercised in seeing that the central mounting, whether it be shafting or pipe, be fairly straight.

In the making of screw conveyors, as in anything else, the policy of starting the job right and catching an error at its inception rather than to correct or to adjust it at the end, is the only sane one. It may be even more desirable in the case of the conveyor as opposed to rather rough metal work since the very use to which the screw conveyor is to be put automatically precludes the possibility of hiding poor workmanship and patchwork adjustments by means of the great coverer of multitudinous sins—paint.

From the collaring operation with its simple inspection, the pipe goes to the facing operation during which the ends are squared up with the axis and the over-all length is brought to exact size. In the case of pipes requiring outside collars only, there is no particular reason why this operation of facing should be anything more than a smoothing operation since the pipe itself is cold during the collaring so that there is none of the upsetting effect which might conceivably alter the cut length in the case of internally collared pipes.

However, it is highly desirable that the length itself be maintained within close limits of what little allowance there may be made in the under length. In laying out a complete installation with its hangers, bearings and box end, it is possible to set in and shorten the overall length of the assembled parts more easily and with less noticeable error than were the case reversed and the box and its fittings lengthened.

The simplest form of facing machine consists of a revolving head or quill upon which is mounted a universal chuck and a dead tail block which holds a hardened stud upon which the inside of the end of the pipe revolves. This acts as a length gage, the desired measurement being laid out from the stop surface of the tail block to the swinging gage arm mounted just in front of the chuck face in such a manner that the operator can readily check the work as it revolves.

The actual facing is performed with a single tool mounted in a toolpost in such a manner that motions inward towards the axis of the work and parallel to that axis can be imparted to it by means of suitable handwheels. In practice, the operator picks up a pipe, slides it through the chuck and against the tail block, and clamps it in place with the chuck. He then takes a skin cut from the first end, making no attempt to reduce the length but only truing it up. The machine is stopped, the chuck released, the pipe withdrawn, turned end for end and reclamped. Restarting the machine, the operator now faces this second end until the swinging stop gage passes freely by the end. A later development of this equipment is fitted with a chuck of the "wrenchless" type instead of the universal chuck, resulting in a considerable saving in time.

However, as will be observed, in either of these two methods it is necessary to make two complete starts, chuckings and facing operations. To make this unnecessary a new type of machine equipped with two facing heads that are capable of being brought together to a stop, has been designed. With this equipment only one chucking of the pipe is necessary. This will save considerable time and effort on the long runs of identical lengths, which are frequently encountered.

In most installations of a screw conveyor the conveyor is hung in bearings by means of couplings, drive or tail ends inserted into the collared ends of the pipe. In order that these may properly be attached it is necessary that bolt holes be drilled through the end of the pipe with a spacing such as will match with a corresponding drilling in the couplings or end shafts. This work is commonly handled on single-spindle drill presses with automatic feed, one man operating two machines.

The spacing is obtained by means of box jigs, fitted with stud arbors which are driven into the collared ends of the pipe until the faced ends of the latter stop against a hardened shoulder at the base of the jig stud.

In this case again, as with the facing operation, the fact that the drilling of each pipe involves a one-quarter turn of the pipe for each end and one end-for-end shift of the pipe and the jig for each length handled, indicates the desirability of a double-end machine with two spindles space 90 deg. apart on each end. But there is always to be considered the question of length of run and variety of length for given sizes of pipe, so that with the short deliveries which are the rule in the screw conveyor business, it becomes impracticable to hold up scattered items to get a "run." There is, very evidently, a field for both types of equipment.

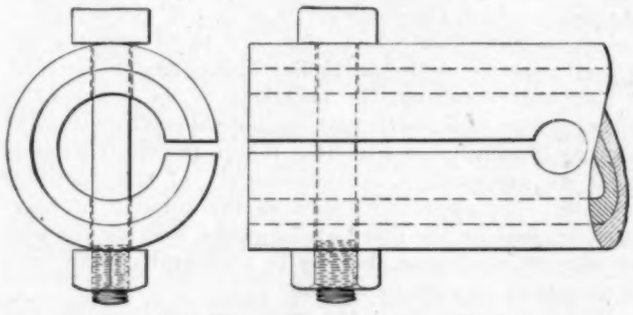


Fig. 18—Slotted pipe ends for nut locking

On large orders of either job or stock, the double-end machine is highly profitable in both the facing and drilling operation but for odd jobs and small order work, the single tool equipment is the most feasible.

In the case of internally collared pipes it is the practice, under certain conditions, to slot one side of the collared ends. The nut of the coupling bolt can then be tightly drawn up against the "spring" of the slotted end and it will then lock itself as shown in Fig. 18.

This slotting operation is performed, directly after the drilling, in a modified form of the slab milling machine fitted with a gang of milling saws which are fed by means of the regular table traverse into the pipe. The latter is held by means of a special gang fixture mounted on the table.

With the forming of the flights and the drilling of the coupling bolt holes in the ends of the pipe, the parts are ready for the final assembly, in the case of the sectional flight conveyor. This consists of mounting the individual flight sections upon the central pipe or shaft, riveting the ends of the flight sections together and securing the spiral thus formed to the backbone by means of suitable attachment lugs.

It is readily apparent that the task of riveting together the sections of a spiral in such a manner as to make a neat and secure job, is not always easy and often requires some little ingenuity, especially in the case of the smaller sizes where the available working space is small. In the larger sizes, more than 6 in. in diam., however, it is possible to work satisfactorily between the turns of the spiral and a very good job is done by means of pneumatic riveters of the "toggle" type.

One of the well-known makers of screw conveyors has set his riveters in fixed locations, merely allowing sufficient pivotal motion about a horizontal axis to permit the jaws to be adjusted to either right-hand or left-hand spirals. With this method of machine setting, the flights, pipe and rivets are brought together at a movable bench in front of the riveting machine and very good speed can be made by an experienced assembler.

Another arrangement favored in the manufacture of both sectional and continuous flight conveyors, because of its ready adaptability to both types, is one wherein the riveting machine is counterweighted and swung from an overhead trolley under which the conveyor is assembled on a bench. The latter is so mounted on track wheels that it also has a considerable possible travel in an endwise direction.

Behind the bench blocks upon which the conveyor pipe or shaft is placed and in which it is free to rotate, is a shelf conveniently located as to height and accessibility to the assembler, which holds punches, sets, rivets, hammers, drifts and chisels.

In assembling sectional flights, it will be found that a perfect flight should fit the backbone with a decided snap and not merely lie around it. In other words, the extra length beyond the full 360 deg. should be accompanied by sufficient extra so that the ends of the flight will require springing into position over the curve of the center. When the forming operation has failed to leave this condition and the ends do not lie accurately together, a blow or two with a three-pound hammer will usually remedy the defect.

The usual method for attaching flighting to its backbone is to use lugs with flatted ends for attachment to the flights and round ends for attachment to the pipe. These may be threaded into the pipe or driven clear through the pipe and riveted on the opposite side. A few specimens of typical lugs are illustrated in Fig. 19. The through or center lugs are usually located after the complete spiral is in place so that there will be no question about its laying snugly against the flight and affording a maximum support to the latter.

In the case of continuous flight conveyors, before they are ready for the assembling bench the flighting must be screwed or threaded onto the center shaft or pipe.

Unlike the sectional conveyor where slight inequalities in pitch and where assembly convenience make it desirable to locate center lug holes after the spiral is riveted, the continuous flight conveyor requires but one trip to the drill press, since it is possible for the

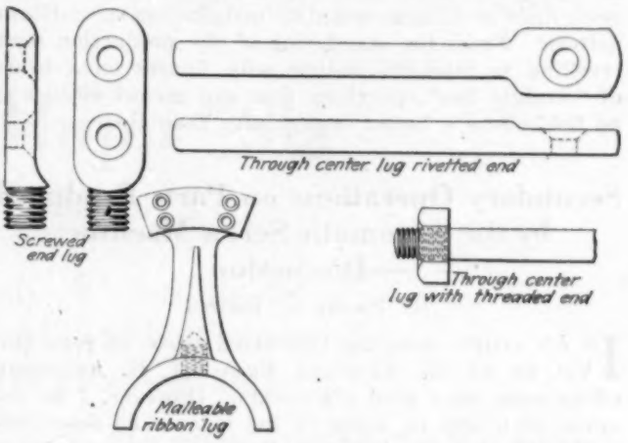


Fig. 19—Lugs for fastening flights to "backbones"

operator to perceive at that time just where it is safe to locate the lug holes in order to secure a tight assembly.

Since the actual assembling of continuous flight conveyors consists only in placing end and center lugs and attaching the flighting to these lugs, the work is very conveniently handled with the same equipment used in the case of the sectional flighting. However, owing to the practically unavoidable necessity for a certain amount of fitting in the case of sectional flights and the many inter-flight joints found in this type, it is usually considered best that this work be given only to the older and more experienced men. The "green" man gets his working knowledge of the assembly equipment on continuous flight jobs and he graduates from this to sectional and ribbon assemblies, successively.

In the case of ribbon flighting, the operations are substantially the same as those for continuous flighting except for the fact that, owing to the space between the flighting and the backbone, it is necessary to first lay out and drill the holes for the attachment lugs and, after locating these in their proper places, to fit the flighting at its proper height above the center, holding it in position with a small type of C-clamp until it is possible to punch holes and rivet it into position.

For convenience, the pneumatic riveters are equipped with slip bushings so as to make it possible to interchange promptly the necessary punches, dies and rivet sets for the different sizes. Without shifting his own or the work's position the assembler can then locate a fastening and secure it in place.

This article covers briefly the high spots in the routine processes connected with the manufacture of standard types of screw conveyors. No attempt has been made to cover all of the multitudinous special features upon which a maker of this sort of equipment must be prepared to quote, since, unfortunately, it seems impossible to forecast the depths of originality to which buyers, designers and experimenters seem

willing to descend, and hence any attempt to enumerate some of the freaks encountered would be to touch upon isolated cases only. However, in spite of the fact that there seems to be an endless variety of demands from the market and a recognized maker is continually finding his books full of orders for odd specifications, the real screw conveyor business lies in the practically standard, quantity production of stock lines or in large-quantity installations of uniform pattern. From the standpoint of the production man revelling in intensive output with figures on a basis of "straight-line" operation, flow and utmost efficiency, no field offers a better opportunity than this.

Secondary Operations on Parts Produced by the Automatic Screw Machine —Discussion

By Harry G. Brown

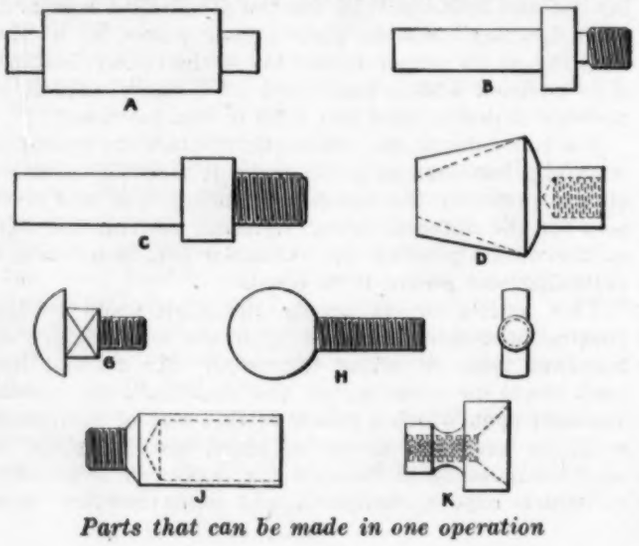
IN AN article under the title given above, on page 467, Vol. 64, of the *American Machinist*, H. Applegard offers some very good arguments. However, I do not agree with him on some of the layouts as described.

Take example A. Assuming that the tenons are drawn to scale, they could be formed very readily on the automatic. If the length of the tenons were three or four times the diameter, I would suggest turning the front tenon with a box tool and turning the rear tenon with swing tool having a support in it, making the piece complete in one operation.

To complete example *B* in one operation; turn the thread size, form the neck with a swing tool and support, thread, rough form the plain body, and finish turn it with swing tool, making the piece complete. I would suggest that in making *B* by two operations, the sequence should be to turn the long tenon and form the thread diameter in the first operation. Roll the thread on a roll threader in second operation.

Example *C* can be done in the same way as *B*, except it is not necked. By rolling the thread, a full thread can be made up to the shoulder.

Example *D*. Drilling and tapping it as shown would be a good job for any automatic screw machine to complete in one operation. However, if the diameter of the taper runs down very small, as shown by the dotted lines, I think the following operations would be in order on the automatic: spot, drill, tap, rough-form taper, and finish-form the tapped end while drilling. After tapping, form and turn at the same time with a swing tool.



Parts that can be made in one operation

Example *G* can be made complete on an automatic screw machine by forming, threading, and milling the square with two turret milling-attachments. However, directly under the head there would be a radius equal to that of the cutters used. This method would be all right if the quantities were large enough. However, if quantities were small, I would suggest making the piece in two operations; forming, and threading in the first operation, then milling the square on a two-spindle miller, using a die block and air plunger to hold it while performing the secondary operation.

Example *H*. If quantities are large enough, I would make this part from special drawn stock, and make it complete in one operation.

Example *J* is an ideal piece to make on the automatic complete, since it is brass. The order of operations would be as follows: spot, drill, and form thread size to pitch diameter. Roll thread with thread roll, either with the cross-slide or swing tool.

Example *K* can be made complete on the automatic. Operations would be as follows: knurl, countersink, drill, form, and tap, providing the depth of tapping is not over three and one-half times the diameter, otherwise do the tapping in a secondary operation.

All these operations are based on doing the work in Brown & Sharpe automatic screw machines.

Solving the Personal Equation

By W. F. Sandmann

"Well, at last we have that valve job licked," announced the superintendent, with a satisfied smile, as he entered the general manager's office. "Same old story. When you can get around the personal element you are on the track to success in this production game."

The manager was amused. "So you have gotten around the personal element, Jackson? In other words, you have succeeded in solving the personal equation?"

"That special automatic machine does the trick," put in the superintendent. "The material goes in rough and the finished valve comes out. No calipers or gages required. The machine operates at the proper speed; in fact, the only speed it has is the proper one."

"How about the feeding of the material to the machine? Don't you have a man for that?" the manager asked.

"No sir! It isn't necessary. The machine has loading fingers that pick the stock off of the conveyor."

"How is the machine built to withstand wear?" inquired the manager.

"Best you ever have seen," replied the superintendent. "Every part extra heavy—nothing complicated. Should run right along for years; at least many times longer than that present valve job. Yes, sir, it is the only machine, and the valve job the only job, where we have gotten away from the personal element."

The manager's phone bell rang. A voice inquired if the superintendent was there. "If he is," the voice continued, "tell him that some darn fool forgot to oil up this new valve automatic, and all of the bearings are shot."

The manager sighed as the door slammed behind the retreating superintendent. "Guess this personal equation stuff would go better under the name of eternal equation."

Automotive Production

Rods for the Hupp "Six"

By Fred H. Colvin
Editor, *American Machinist*

Holding fixtures for rods—Elongating the holes in the large ends—Milling bolt bosses and cutting off caps—Oil-grooving device

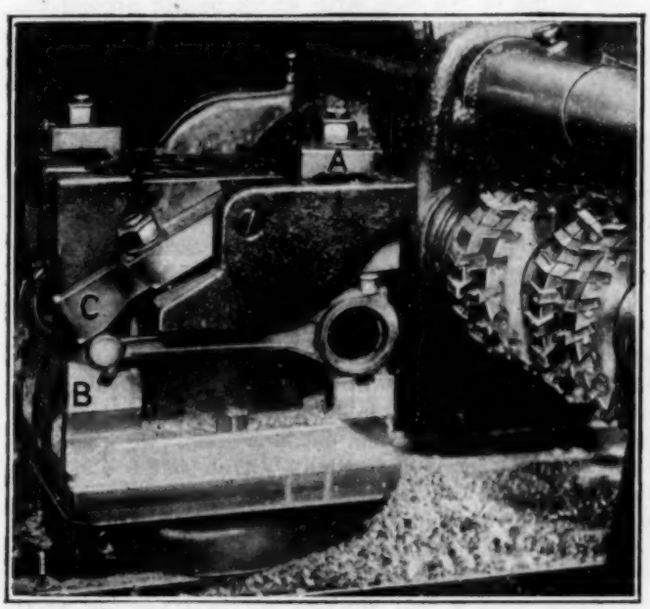
THE connecting rod fixtures used on the Hupp rods are somewhat different in design from those usually used, although the methods of machining them are, naturally, quite similar. Fig. 1 shows the shape of the rod and the way in which it is held for milling the ends of the bearings. The large end is located in the lower V-block and is held by a smaller V-block on top, forced down by the strap *A*, bearing on the upper end of the clamping plunger. The small end of the rod is located in the block *B*, being held in position by the strap *C*. Being at the angle shown, the strap holds the rod down and forces it against the stop at the same time.

Two rods are held in the fixture, one on each side but in reverse positions, so that the large end of one rod and the small end of the other one are milled by separate pairs of cutters at the same table movement. The fixture is then indexed 180 deg. and the operation repeated. This method allows two rods to be milled at each loading of the fixture.

The hole in the large end is elongated before cutting off the cap, to allow for the metal removed by the saw. The operation is done in the fixture shown in Fig. 2, where the rod is first bored in the regular way. The boring tool then cuts out one side of the hole, leaving it oval in shape, ready to have the cap cut off. The next operation is to drill and tap the hole for the clamping screw at the small end.

The bolt holes are next drilled, the rods being held in the three-lobed fixture, Fig. 3. Each lobe carries two rods on each side, so that four rods are drilled in the first position and reamed in the second, four rods being completely drilled and reamed at each indexing of the fixture.

The bolt bosses are milled and the caps cut off on the rotating fixture in Fig. 4. The rods are located by



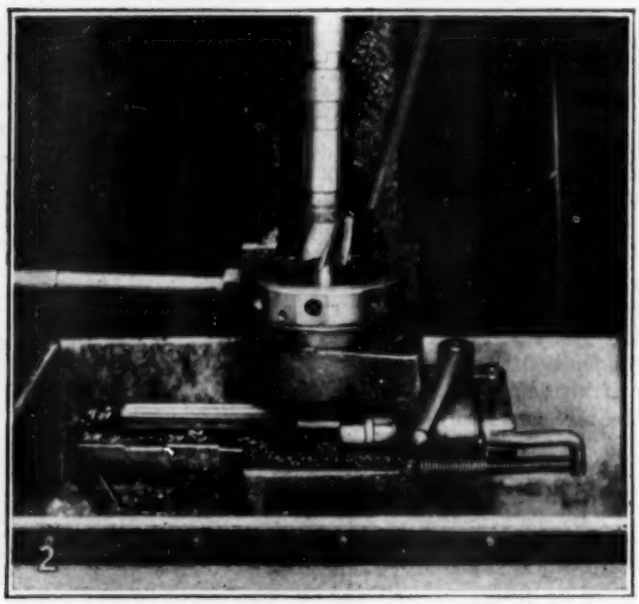
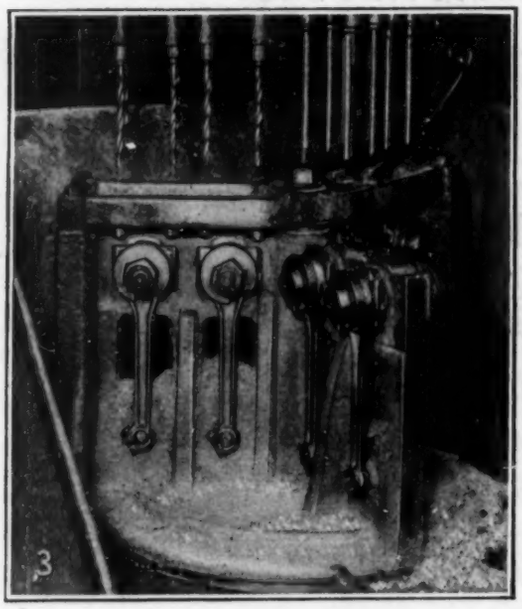


Fig. 1—Double fixture for first operation. Fig. 2—Elongating the large hole

Automotive Production



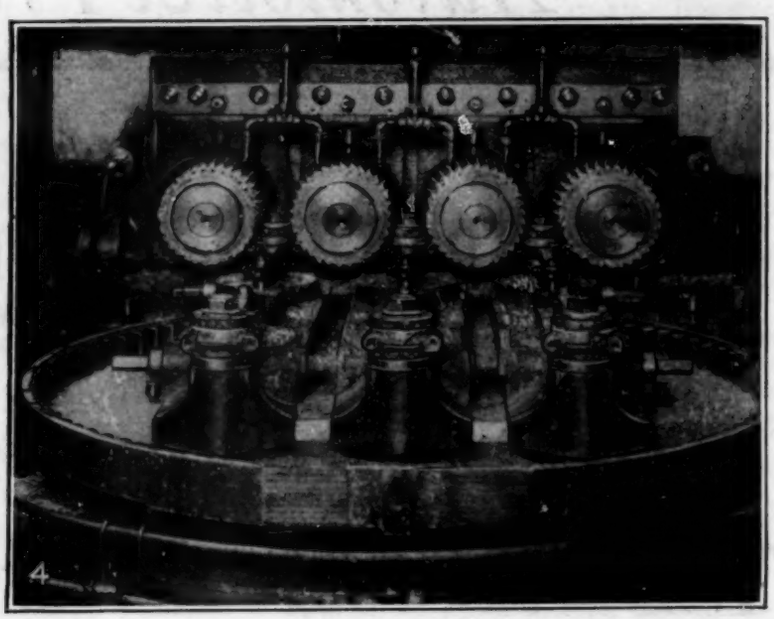


Fig. 3—Drilling and reaming bolt holes. Fig. 4—Cutting off the caps

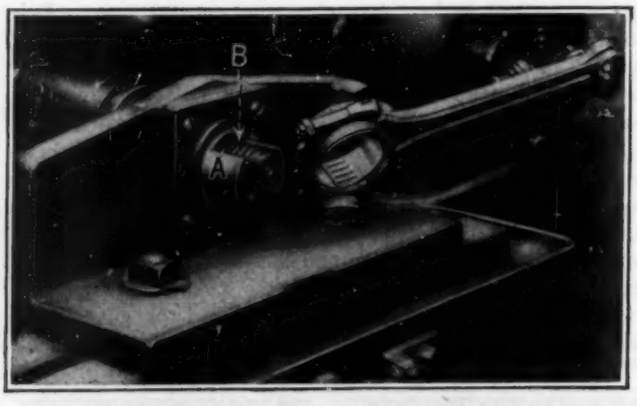


Fig. 5—Milling oil grooves in bearing

the holes at each end, and are held by C-washers over the large end. The four sets of cutters mill the bolt bosses and cut off the caps of three rods at each pass. The cutters are flooded with coolant from the pipes shown.

The large end is then tinned, bored and broached, after which the oil grooves at the sides of the bearing are cut with the device shown in Fig. 5. The rod is carried on the support *A*, surrounding the cutter *B* on the spindle, the small end fitting over a pin that is hidden behind the rod. The grooves are cut in the babbitt inside the large end of the rod as shown, by moving the table up and down against stops.

Exasperating Jobs

BY ENTROPY

Jim is in mourning once more. This time he is down on designers. He says no one ought to be allowed to design machinery except a machinist. He thinks all draftsmen should be shot during the night, sees no object in waiting for sunrise as is the usual custom.

The particular thing that exasperates him right now is, like most of our troubles in this vale of tears, his own fault. He did not look at the drawings of a machine he figured on until after he got the order. That is, he did not look at them closely enough to discover that the draftsman put several of the finished surfaces back of projecting brackets, and undercuts in deep recesses. If he had looked at the drawings before he made his bid, he would have made it so high that someone else would have had the job.

Of course, the truth is that Jim was complaining about these inaccessible finished spots so that he could brag to me of the ease with which he got around the difficulty. He is building the machine, because he is that sort of a chap. Anything that seems difficult is a challenge to him to find a way to do it. If he charged the customer for his own time thinking up ways to do a job at a rate that is commensurate with his experience, the customer would never have that particular draftsman do another job of designing.

There is something to be said on the other side. The man who designs a machine with inaccessible spots may have in mind some simple fixture to make them easy to handle when quantity production is entered upon. He may realize perfectly well that the first machine will cost a great deal of money, but he may expect to save it on future lots. But, no matter how good a face can be put on it, there is no doubt that many designers spend little time finding out how their work can be machined, and it is unfortunately true that few capable machinists feel any urge to go into the drafting room.

Some time, I suppose, we shall have a board of licensing draftsmen just as for dentists and lawyers. When we do, I hope that it will insist that every draftsman spend at least a year working at the trade for which he is making drawings before he is allowed to apply for a job.

The Design of Gear Tooth Forms

By Earle Buckingham
Associate Professor of Engineering Standards and Measurements
Massachusetts Institute of Technology

Relative sliding between two 10-tooth pinions, two 40-tooth gears, and a 10-tooth pinion and a 40-tooth gear of the 14½-deg. variable center system — Table of center distances, pressure angles and tooth depths

CONTINUING the example started in the fifteenth article in which two 10-tooth pinions of the 14½-deg. variable center involute system were in contact, we will examine the sliding conditions on this pair. We have from equation (23) in the sixth article

Specific sliding on pinion $= \frac{b_1N_2 - b_2N_1}{b_1N_2}$, where

b_1 = radius of curvature of any point on pinion tooth profile
b_2 = radius of curvature of mating point on gear tooth profile
N_1 = number of teeth in pinion
N_2 = number of teeth in gear.

In this case, the active profile of the pinion extends to the tip of the tooth so that the maximum radius of curvature of the active profile is equal to $\sqrt{E^2 - a^2}$, which equals 3.9924 in. The minimum radius of curvature of the active profile is equal to the total length of the line of action minus the maximum radius of curvature, or 1.0690 in. in this example. Whence we have

Specific sliding at

$$\text{beginning of contact} = \frac{1.0690 - 3.9924}{1.0690} = -2.79$$

The values of b_1 and b_2 are reversed at the end of contact, whence we have

$$\text{Specific sliding} = \frac{3.9924 - 1.0690}{3.9924} = +0.74$$

This specific sliding is plotted in Fig. 70. A comparison of this chart with Figs. 49, 56 and 64 in previous articles shows that the sliding conditions on these 10-tooth pinions are much more favorable than on the 22-tooth, 14½-deg. generated gears; the 14-tooth, 20-deg. full depth gears; and the 12-tooth, 20-deg. stub tooth gears of the standard systems.

Although the contact on these 10-tooth pinions is too short to permit them to be used for the transmission of power, we will use them as the start of a variable center distance system of gears. The next step will be to consider the larger gears of such a system. We know that as the numbers of teeth become larger, smaller pressure angles become more effective. These 10-tooth pinions mesh with a pressure angle of over 27 deg. When the tooth numbers are forty or larger, for example, the pressure angle of 14½ deg. is a very good one. We will therefore make all the gears of this system of standard proportions that have forty teeth or more. This will mean that when the smallest gear of a pair has forty teeth or more, the gears will mesh at proportional or standard center distances with a pressure angle of 14½ deg. Thus the need of variable center distances will be limited to those drives where one or more of the gears have less than forty teeth. Also, this variable center distance system will be an extension of the existing 14½-deg. generated system rather than an entirely new system of gear teeth.

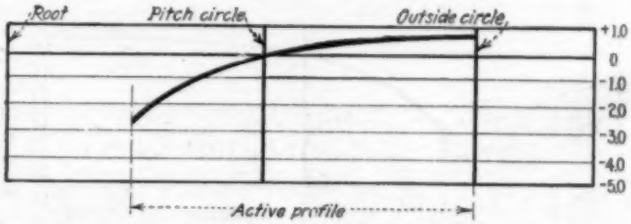


Fig. 70—Specific sliding between two 10-tooth pinions, 14½-deg. variable center system

This extension is necessary in order to obtain more effective gears of small tooth numbers.

In this system the 40-tooth gear of 1 D.P. will therefore have the following values:

E = 21.0000 in. = outside radius
R = 20.0000 in. = nominal pitch radius
H = 18.8000 in. = root radius
f = 0.2000 in. = clearance on generating rack
$\alpha = 14\frac{1}{2}°$ = pressure angle of basic rack
$a = R\cos\alpha$ = 19.3629 in. = radius of base circle
T = 1.5708 in. = tooth thickness at R.

We will examine the contact conditions on a pair of these 40-tooth gears when they mesh together. We have from equation (58) in the thirteenth article:

$$\text{Number of teeth in contact} = \frac{\sqrt{E_1^2 - a_1^2} + \sqrt{E_2^2 - a_2^2} - C\sin\alpha}{Pn}$$

In this example, both gears are equal, therefore

$\sqrt{E^2 - a^2}$ = 8.1287
Pn = 3.0415 in.
$C\sin\alpha$ = 10.1520 in.

$$\text{Whence contact} = \frac{6.1054}{3.0415} = 2.007 \text{ tooth intervals.}$$

This contact is ample. We will also examine the sliding conditions. We have from the sixth article

Specific sliding on pinion $= \frac{b_2N_2 - b_2N_1}{b_1N_2}$, where

The sixteenth article. The seventeenth will appear in an early issue.

b_1 = radius of curvature of any point on pinion tooth profile

b_2 = radius of curvature of mating point on gear tooth

N_1 = number of teeth in pinion

N_2 = number of teeth in gear.

In this example, the active profiles of the teeth of the gears extend to their tips so that the maximum radius of curvature of the active profile is equal to $\sqrt{E^2 - a^2}$, which equals 8.1287 in. The minimum radius of curvature is equal to the total length of the line of action minus this maximum radius of curvature, or 2.0233 in. in this example. Whence we have

$$\text{Specific sliding at beginning of contact} = \frac{2.0233 - 8.1287}{2.0233} = -3.02$$

The values of b_1 and b_2 are reversed at the end of contact, whence we have

$$\text{Specific sliding} = \frac{8.1287 - 2.0233}{8.1287} = +0.75$$

This specific sliding is plotted in Fig. 71, and it shows very favorable sliding conditions.

We will now examine the contact conditions when the 10-tooth pinion and the 40-tooth gear are meshed

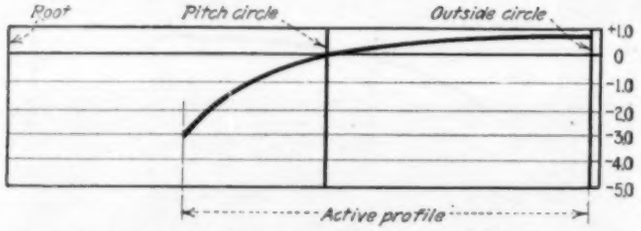


Fig. 71—Specific sliding between two 40-tooth gears, 14½-deg. variable center system

together. We will first determine the pressure angle and the center distance at which they will operate. We have from problem 8, in the seventh article:

$$\text{inv}\,a_2 = \frac{n(t_1 + T_1) - 2\pi r_1'}{2r_1(n + N)} + \text{inv}\,a_1 \qquad \text{[Equation (43)]}$$

$$C_2 = \frac{C_1 \cos a_1}{\cos a_2} \qquad \text{[Equation (44)]}$$

In this example,

r_1 = 14½-deg. pitch radius of pinion = 5.0000 in.

t_1 = tooth thickness of pinion at r_1 = 1.9259 in.

n = number of teeth in pinion = 10

a_1 = pressure angle at r_1 and R_1 = 14½°

R_1 = 14½-deg. pitch radius of gear = 20.0000 in.

T_1 = tooth thickness of gear at R_1 = 1.5708 in.

N = number of teeth in gear = 40

C_1 = center distance for 14½-deg. pressure angle = 25.0000 in.

a_2 = pressure angle of gears when meshed

C_2 = center distance at which gears mesh.

Whence

$$\text{inv}\,a_2 = \frac{10(1.9259 + 1.5708) - 31.4160}{10(10 + 40)} + 0.005545$$

$$= 0.012647$$

From the table of involute functions in the seventh article we get

$a_2 = 18°58'$, whence $\cos a_2 = 0.94571$

$$C_2 = \frac{25 \times 0.96815}{0.94571} = 25.5931 \text{ in.}$$

Table XI—Fundamental Dimensions of 1 D.P. Gears of the 14½-Deg. Basic-Rack, Variable-Center System

No. of Teeth N	14½-Deg. Pitch Radius R, In.	Radius of Base Circle, a, In.	Undercut Radius A, In.	Root Radius H, In.	Tooth Thickness at R T, In.
10	5.0	4.84074	4.48655	4.48655	1.92591
11	5.5	5.32481	4.95520	4.96367	1.91407
12	6.0	5.80889	5.42386	5.44078	1.90224
13	6.5	6.29296	5.89251	5.91790	1.89040
14	7.0	6.77703	6.36117	6.39501	1.87856
15	7.5	7.26111	6.82982	6.87213	1.86673
16	8.0	7.74518	7.29848	7.34924	1.85489
17	8.5	8.22925	7.76713	7.82636	1.84305
18	9.0	8.71333	8.23579	8.30347	1.83121
19	9.5	9.19740	8.70444	8.78059	1.81938
20	10.0	9.68148	9.17310	9.25770	1.80754
21	10.5	10.16555	9.64175	9.73482	1.79570
22	11.0	10.64962	10.11041	10.21193	1.78387
23	11.5	11.13370	10.57906	10.68905	1.77203
24	12.0	11.61777	11.04772	11.16616	1.76019
25	12.5	12.10185	11.51637	11.64328	1.74836
26	13.0	12.58592	11.98503	12.12039	1.73652
27	13.5	13.06999	12.45368	12.59751	1.72468
28	14.0	13.55407	12.92234	13.07462	1.71284
29	14.5	14.03814	13.39099	13.55174	1.70101
30	15.0	14.52221	13.85965	14.02885	1.68917
31	15.5	15.00629	14.32830	14.50597	1.67733
32	16.0	15.49036	14.79696	14.98308	1.66550
33	16.5	15.97444	15.26561	15.46020	1.65366
34	17.0	16.45851	15.73427	15.93731	1.64182
35	17.5	16.94258	16.20292	16.41443	1.62999
36	18.0	17.42666	16.67158	16.89154	1.61815
37	18.5	17.91073	17.14023	17.36866	1.60631
38	19.0	18.39481	17.60889	17.84577	1.59447
39	19.5	18.87888	18.07754	18.32289	1.58264
40	20.0	19.36295	18.54620	18.80000	1.57080
41	20.5	19.84703		19.3000	1.57080
42	21.0	20.33110		19.8000	1.57080
43	21.5	20.81517		20.3000	1.57080
44	22.0	21.29925		20.8000	1.57080
45	22.5	21.78332		21.3000	1.57080
46	23.0	22.26740		21.8000	1.57080
47	23.5	22.75147		22.3000	1.57080
48	24.0	23.23554		22.8000	1.57080
49	24.5	23.71962		23.3000	1.57080
50	25.0	24.20369		23.8000	1.57080
51	25.5	24.68776		24.3000	1.57080
52	26.0	25.17184		24.8000	1.57080
53	26.5	25.65591		25.3000	1.57080
54	27.0	26.13999		25.8000	1.57080
55	27.5	26.62406		26.3000	1.57080
56	28.0	27.10813		26.8000	1.57080
57	28.5	27.59221		27.3000	1.57080
58	29.0	28.07628		27.8000	1.57080
59	29.5	28.56036		28.3000	1.57080
60	30.0	29.04443		28.8000	1.57080

The tooth depths will be established as before, whence

$$1.200 \times \text{working depth} = 25.5931 - (18.80000 + 4.4866) = 2.3065 \text{ in.}$$

Working depth = 1.9221 in.

Clearance = 0.1922 in.

Whole depth = 2.1143 in.

E_1 = 4.4866 + 2.1143 = 6.6009 in. = outside radius of pinion

E_2 = 18.80000 + 2.1143 = 20.9143 in. = outside radius of gear.

We will now examine the contact conditions for this

Table XII—Center Distances, Pressure Angles, and Tooth Depths—14½-Deg. Basic Rack, Variable-Center System—1 D. P. Gears

No. of Teeth in Gear		Number of Teeth in Pinion											
		10	11	12	13	14	15	16	17	18	19	20	21
10	Center Distance, In.	10.9247											
	Pressure Angle	27 –36′											
	Tooth Depth, In.	1.7889											
11	Center Distance, In.	11.4195	11.9143										
	Pressure Angle	27°–7′	26°–40′										
	Tooth Depth, In.	1.8052	1.8214										
12	Center Distance, In.	11.9143	12.4091	12.9039									
	Pressure Angle	26°–40′	26°–14′	25°–49′									
	Tooth Depth, In.	1.8214	1.8376	1.8538									
13	Center Distance, In.	12.4091	12.9039	13.3987	13.8905								
	Pressure Angle	26°–14′	25°–49′	25°–25′	25°–3′								
	Tooth Depth, In.	1.8376	1.8538	1.8700	1.8835								
14	Center Distance, In.	12.9039	13.3987	13.8905	14.3823	14.8741							
	Pressure Angle	25°–49′	25°–25′	25°–3′	24°–41′	24°–20′							
	Tooth Depth, In.	1.8538	1.8700	1.8835	1.8970	1.9105							
15	Center Distance, In.	13.3987	13.8905	14.3823	14.8741	15.3659	15.8577						
	Pressure Angle	25°–25′	25°–3′	24°–41′	24°–20′	24°–0′	23°–41′						
	Tooth Depth, In.	1.8700	1.8835	1.8970	1.9105	1.9239	1.9373						
16	Center Distance, In.	13.8905	14.3823	14.8741	15.3659	15.8577	16.3473	16.8369					
	Pressure Angle	25°–3′	24°–41′	24°–20′	24°–0′	23°–41′	23°–23′	23°–5′					
	Tooth Depth, In.	1.8835	1.8970	1.9105	1.9239	1.9373	1.9488	1.9603					
17	Center Distance, In.	14.3823	14.8741	15.3659	15.8577	16.3473	16.8369	17.3264	17.8160				
	Pressure Angle	24°–41′	24°–20′	24°–0′	23°–41′	23°–23′	23°–5′	22°–48′	22°–31′				
	Tooth Depth, In.	1.8970	1.9105	1.9239	1.9373	1.9488	1.9603	1.9717	1.9831				
18	Center Distance, In.	14.8741	15.3659	15.8577	16.3473	16.8369	17.3264	17.8160	18.3056	18.7930			
	Pressure Angle	24°–20′	24°–0′	23°–41′	23°–23′	23°–5′	22°–48′	22°–31′	22°–15′	21°–59′			
	Tooth Depth, In.	1.9105	1.9239	1.9373	1.9488	1.9603	1.9717	1.9831	1.9945	2.0040			
19	Center Distance, In.	15.3659	15.8577	16.3473	16.8369	17.3264	17.8160	18.3056	18.7930	19.2805	19.7679		
	Pressure Angle	24°–0′	23°–41′	23°–23′	23°–5′	22°–48′	22°–31′	22°–15′	21°–59′	21°–44′	21°–29′		
	Tooth Depth, In.	1.9239	1.9373	1.9488	1.9603	1.9717	1.9831	1.9945	2.0040	2.0135	2.0230		
20	Center Distance, In.	15.8577	16.3473	16.8369	17.3264	17.8160	18.3056	18.7930	18.2805	19.7679	20.2554	20.7428	
	Pressure Angle	23°–41′	23°–23′	23°–5′	22°–48′	22°–31′	22°–15′	21°–59′	21°–44′	21°–29′	21°–15′	21°–1′	
	Tooth Depth, In.	1.9373	1.9488	1.9603	1.9717	1.9831	1.9945	2.0040	1.0135	2.0230	2.0324	2.0418	
21	Center Distance, In.	16.3473	16.8369	17.3264	17.8160	18.3056	18.7930	19.2805	19.7679	20.2554	20.7428	21.2285	21.7143
	Pressure Angle	23°–23′	23°–5′	22°–48′	22°–31′	22°–15′	21°–59′	21°–44′	21°–29′	21°–15′	21°–1′	20°–47′	20°–34′
	Tooth Depth, In.	1.9488	1.9603	1.9717	1.9831	1.9945	2.0040	2.0135	2.0230	2.0324	2.0418	2.0497	2.0576
22	Center Distance, In.	16.8369	17.3264	17.8160	18.3056	18.7930	19.2805	19.7679	20.2554	20.7428	21.2285	21.7143	22.2000
	Pressure Angle	23°–5′	22°–48′	22°–31′	22°–15′	21°–59′	21°–44′	21°–29′	21°–15′	21°–1′	20°–47′	20°–34′	20°–21′
	Tooth Depth, In.	1.9603	1.9717	1.9831	1.9945	2.0040	2.0135	2.0230	2.0324	2.0418	2.0497	2.0576	2.0655
23	Center Distance, In.	17.3264	17.8160	18.3056	18.7930	19.2805	19.7679	20.2554	20.7428	21.2285	21.7143	22.2000	22.6858
	Pressure Angle	22°–48′	22°–31′	22°–15′	21°–59′	21°–44′	21°–29′	21°–15′	21°–1′	20°–47′	20°–34′	20°–21′	20°–8′
	Tooth Depth, In.	1.9717	1.9831	1.9945	2.0040	2.0135	2.0230	2.0324	2.0418	2.0497	2.0576	2.0655	2.0734
24	Center Distance, In.	17.8160	18.3056	18.7930	19.2805	19.7679	20.2554	20.7428	21.2285	21.7143	22.2000	22.6858	23.1715
	Pressure Angle	22°–31′	22°–15′	21°–59′	21°–44′	21°–29′	21°–15′	21°–1′	20°–47′	20°–34′	20°–21′	20°–8′	19°–56′
	Tooth Depth, In.	1.9831	1.9945	2.0040	2.0135	2.0230	2.0324	2.0418	2.0497	2.0576	2.0655	2.0734	2.0813
25	Center Distance, In.	18.3056	18.7930	19.2805	19.7679	20.2554	20.7428	21.2285	21.7143	22.2000	22.6858	23.1715	23.6558
	Pressure Angle	22°–15′	21°–59′	21°–44′	21°–29′	21°–15′	21°–1′	20°–47′	20°–34′	20°–21′	20°–8′	19°–56′	19°–44′
	Tooth Depth, In.	1.9945	2.0040	2.0135	2.0230	2.0324	2.0418	2.0497	2.0576	2.0655	2.0734	2.0813	2.0879
26	Center Distance, In.	18.7930	19.2805	19.7679	20.2554	20.7428	21.2285	21.7143	22.2000	22.6858	23.1715	23.6558	24.1401
	Pressure Angle	21°–59′	21°–44′	21°–29′	21°–15′	21°–1′	20°–47′	20°–34′	20°–21′	20°–8′	19°–56′	19°–44′	19°–32′
	Tooth Depth, In.	2.0040	2.0135	2.0230	2.0324	2.0418	2.0497	2.0576	2.0655	2.0734	2.0813	2.0879	2.0945
27	Center Distance, In.	19.2805	19.7679	20.2554	20.7428	21.2285	21.7143	22.2000	22.6858	23.1715	23.6558	24.1401	24.6245
	Pressure Angle	21°–44′	21°–29′	21°–15′	21°–1′	20°–47′	20°–34′	20°–21′	20°–8′	19°–56′	19°–44′	19°–32′	19°–20′
	Tooth Depth, In.	2.0135	2.0230	2.0324	2.0418	2.0497	2.0576	2.0655	2.0734	2.0813	2.0879	2.0945	2.1011
28	Center Distance, In.	19.7679	20.2554	20.7428	21.2285	21.7143	22.2000	22.6858	23.1715	23.6558	24.1401	24.6245	25.1088
	Pressure Angle	21°–29′	21°–15′	21°–1′	20°–47′	20°–34′	20°–21′	20°–8′	19°–56′	19°–44′	19°–32′	19°–20′	19°–9′
	Tooth Depth, In.	2.0230	2.0324	2.0418	2.0497	2.0576	2.0655	2.0734	2.0813	2.0879	2.0945	2.1011	2.1077
29	Center Distance, In.	20.2554	20.7428	21.2285	21.7143	22.2000	22.6858	23.1715	23.6558	24.1401	24.6245	25.1088	25.5931
	Pressure Angle	21°–15′	21°–1′	20°–47′	20°–34′	20°–21′	20°–8′	19°–56′	19°–44′	19°–32′	19°–20′	19°–9′	18°–58′
	Tooth Depth, In.	2.0324	2.0418	2.0497	2.0576	2.0655	2.0734	2.0813	2.0879	2.0945	2.1011	2.1077	2.1143
30	Center Distance, In.	20.7428	21.2285	21.7143	22.2000	22.6858	23.1715	23.6558	24.1401	24.6245	25.1088	25.5931	26.0759
	Pressure Angle	21°–1′	20°–47′	20°–34′	20°–21′	20°–8′	19°–56′	19°–44′	19°–32′	19°–20′	19°–9′	18°–58′	18°–47′
	Tooth Depth, In.	2.0418	2.0497	2.0576	2.0655	2.0734	2.0813	2.0879	2.0945	2.1011	2.1077	2.1143	2.1196

Table XII—Center Distances, Pressure Angles, and Tooth Depths—14½-Deg. Basic Rack, Variable-Center System—1 D. P. Gears (Continued)

No. of Teeth in Gear		Number of Teeth in Pinion											
		10	11	12	13	14	15	16	17	18	19	20	21
31	Center Distance, In.	21.2285	21.7143	22.2000	22.6858	23.1715	23.6558	24.1401	24.6245	25.1088	25.5931	26.0759	26.5588
	Pressure Angle	20°–47′	20°–34′	20°–21′	20°–8′	19°–56′	19°–44′	19°–32′	19°–20′	19°–9′	18°–58′	18°–47′	18°–36′
	Tooth Depth, In.	2.0497	2.0576	2.0655	2.0734	2.0813	2.0879	2.0945	2.1011	2.1077	2.1143	2.1196	2.1249
32	Center Distance, In.	21.7143	22.2000	22.6858	23.1715	23.6558	24.1401	24.6245	25.1088	25.5931	26.0759	26.5588	27.0416
	Pressure Angle	20°–34′	20°–21′	20°–8′	19°–56′	19°–44′	19°–32′	19°–20′	19°–9′	18°–58′	18°–47′	18°–36′	18°–26′
	Tooth Depth, In.	2.0576	2.0655	2.0734	2.0813	2.0879	2.0945	2.1011	2.1077	2.1143	2.1196	2.1249	2.1302
33	Center Distance, In.	22.2000	22.6858	23.1715	23.6558	24.1401	24.6245	25.1088	25.5931	26.0759	26.5588	27.0416	27.5245
	Pressure Angle	20°–21′	20°–8′	19°–56′	19°–44′	19°–32′	19°–20′	19°–9′	18°–58′	18°–47′	18°–36′	18°–26′	18°–16′
	Tooth Depth, In.	2.0655	2.0734	2.0813	2.0879	2.0945	2.1011	2.1077	2.1143	2.1196	2.1249	2.1302	2.1354
34	Center Distance, In.	22.6858	23.1715	23.6558	24.1401	24.6245	25.1088	25.5931	26.0759	26.5588	27.0416	27.5245	28.0073
	Pressure Angle	20°–8′	19°–56′	19°–44′	19°–32′	19°–20′	19°–9′	18°–58′	18°–47′	18°–36′	18°–26′	18°–16′	18°–5′
	Tooth Depth, In.	2.0734	2.0813	2.0879	2.0945	2.1011	2.1077	2.1143	2.1196	2.1249	2.1302	2.1354	2.1406
35	Center Distance, In.	23.1715	23.6558	24.1401	24.6245	25.1088	25.5931	26.0759	26.5588	27.0416	27.5245	28.0073	28.4894
	Pressure Angle	19°–56′	19°–44′	19°–32′	19°–20′	19°–9′	18°–58′	18°–47′	18°–36′	18°–26′	18°–16′	18°–5′	17°–55′
	Tooth Depth, In.	2.0813	2.0879	2.0945	2.1011	2.1077	2.1143	2.1196	2.1249	2.1302	2.1354	2.1406	2.1452
36	Center Distance, In.	23.6558	24.1401	24.6245	25.1088	25.5931	26.0759	26.5588	27.0416	27.5245	28.0073	28.4894	28.9715
	Pressure Angle	19°–44′	19°–32′	19°–20′	19°–9′	18°–58′	18°–47′	18°–36′	18°–26′	18°–16′	18°– 5′	17°–55′	17°–46′
	Tooth Depth, In.	2.0879	2.0945	2.1011	2.1077	2.1143	2.1196	2.1249	2.1302	2.1354	2.1406	2.1452	2.1498
37	Center Distance, In.	24.1401	24.6245	25.1088	25.5931	26.0759	26.5588	27.0416	27.5245	28.0073	28.4894	28.9715	29.4536
	Pressure Angle	19°–32′	19°–20′	19°–9′	18°–58′	18°–47′	18°–36′	18°–26′	18°–16′	18°–5′	17°–55′	17°–46′	17°–36′
	Tooth Depth, In.	2.0945	2.1011	2.1077	2.1143	2.1196	2.1249	2.1302	2.1354	2.1406	2.1452	2.1498	2.1544
38	Center Distance, In.	24.6245	25.1088	25.5931	26.0759	26.5588	27.0416	27.5245	28.0073	28.4894	28.9715	29.4536	29.9357
	Pressure Angle	19°–20′	19°–9′	18°–58′	18°–47′	18°–36′	18°–26′	18°–16′	18°–5′	17°–55′	17°–46′	17°–36′	17°–26′
	Tooth Depth, In.	2.1011	2.1077	2.1143	2.1196	2.1249	2.1302	2.1354	2.1406	2.1452	2.1498	2.1544	2.1590
39	Center Distance, In.	25.1088	25.5931	26.0759	26.5588	27.0416	27.5245	28.0073	28.4894	28.9715	29.4536	29.9357	30.4178
	Pressure Angle	19°–9′	18°–58′	18°–47′	18°–36′	18°–26′	18°–16′	18°–5′	17°–55′	17°–46′	17°–36′	17°–26′	17°–17′
	Tooth Depth, In.	2.1077	2.1143	2.1196	2.1249	2.1302	2.1354	2.1406	2.1452	2.1498	2.1544	2.1590	2.1635
40	Center Distance, In.	25.5931	26.0759	26.5588	27.0416	27.5245	28.0073	28.4894	28.9715	29.4536	29.9357	30.4178	30.8986
	Pressure Angle	18°–58′	18°–47′	18°–36′	18°–26′	18°–16′	18°–5′	17°–55′	17°–46′	17°–36′	17°–26′	17°–17′	17°–8′
	Tooth Depth, In.	2.1143	2.1196	2.1249	2.1302	2.1354	2.1406	2.1452	2.1498	2.1544	2.1590	2.1635	2.1669
41	Center Distance, In.	26.0941	26.5765	27.0589	27.5413	28.0237	28.5062	28.9886	29.4710	29.9534	30.4358	30.9182	31.3983
	Pressure Angle,	18°–54′	18°–44′	18°–34′	18°–24′	18°–14′	18°–4′	17°–54′	17°–44′	17°–34′	17°–24′	17°–15′	17°–6′
	Tooth Depth, In.	2.1153	2.1205	2.1258	2.1310	2.1361	2.1412	2.1457	2.1502	2.1547	2.1591	2.1636	2.1670
42	Center Distance, In.	26.5952	27.0776	27.5599	28.0423	28.5246	29.0070	29.4893	29.9717	30.4540	30.9364	31.4187	31.8988
	Pressure Angle	18°–50′	18°–40′	18°–30′	18°–20′	18°–10′	18°–0′	17°–50′	17°–40′	17°–31′	17°–22′	17°–13′	17°–4′
	Tooth Depth, In.	2.1162	2.1210	2.1264	2.1313	2.1364	2.1414	2.1459	2.1505	2.1551	2.1595	2.1643	2.1671
43	Center Distance, In.	27.0962	27.5785	28.0608	28.5431	29.0254	29.5077	29.9899	30.4722	30.9545	31.4368	31.9191	32.3992
	Pressure Angle	18°–46′	18°–36′	18°–26′	18°–16′	18°–6′	17°–56′	17°–47′	17°–38′	17°–29′	17°–20′	17°–11′	17°–2′
	Tooth Depth, In.	2.1172	2.1220	2.1267	2.1315	2.1366	2.1415	2.1461	2.1508	2.1554	2.1600	2.1647	2.1675
44	Center Distance, In.	27.5972	28.0794	28.5617	29.0439	29.5262	30.0084	30.4906	30.9729	31.4551	31.9374	32.4196	32.9996
	Pressure Angle	18°–42′	18°–32′	18°–22′	18°–12′	18°–3′	17°–54′	17°–45′	17°–36′	17°–27′	17°–18′	17°–9′	17°–0′
	Tooth Depth, In.	2.1181	2.1228	2.1275	2.1322	2.1369	2.1416	2.1463	2.1510	2.1557	2.1604	2.1651	2.1679
45	Center Distance, In.	28.0983	28.5805	29.0626	29.5448	30.0270	30.5092	30.9913	31.4735	31.9557	32.4378	32.9200	33.4000
	Pressure Angle	18°–39′	18°–29′	18°–19′	18°–9′	18°–0′	17°–51′	17°–42′	17°–33′	17°–24′	17°–15′	17°–6′	16°–58′
	Tooth Depth, In.	2.1191	2.1237	2.1284	2.1330	2.1377	2.1423	2.1469	2.1516	2.1562	2.1609	2.1655	2.1683
46	Center Distance, In.	28.5993	29.0814	29.5635	30.0456	30.5277	31.0099	31.4920	31.9741	32.4562	32.9383	33.4204	33.9004
	Pressure Angle	18°–35′	18°–25′	18°–16′	18°–7′	17°–58′	17°–49′	17°–40′	17°–31′	17°–22′	17°–13′	17°–4′	16°–56′
	Tooth Depth, In.	2.1200	2.1246	2.1292	2.1338	2.1384	2.1430	2.1475	2.1521	2.1567	2.1613	2.1659	2.1687
47	Center Distance, In.	29.1003	29.5824	30.0644	30.5465	31.0285	31.5106	31.9927	32.4747	32.9568	33.4388	33.9209	34.4008
	Pressure Angle	18°–32′	18°–23′	18°–14′	18°–5′	17°–56′	17°–47′	17°–38′	17°–29′	17°–20′	17°–11′	17°–2′	16°–54′
	Tooth Depth, In.	2.1210	2.1255	2.1301	2.1346	2.1391	2.1437	2.1482	2.1527	2.1572	2.1618	2.1663	2.1691
48	Center Distance, In.	29.6013	30.0833	30.5653	31.0473	31.5293	32.0113	32.4933	32.9753	33.4573	33.9393	34.4213	34.9012
	Pressure Angle	18°–29′	18°–20′	18°–11′	18°–2′	17°–53′	17°–44′	17°–35′	17°–26′	17°–17′	17°–8′	17°–0′	16°–52′
	Tooth Depth, In.	2.1219	2.1264	2.1309	2.1353	2.1398	2.1443	2.1488	2.1533	2.1577	2.1622	2.1667	2.1695
49	Center Distance, In.	30.1024	30.5843	31.0663	31.5482	32.0302	32.5121	32.9940	33.4760	33.9579	34.4399	34.9218	35.4016
	Pressure Angle	18°–26′	18°–17′	18°–8′	17°–59′	17°–50′	17°–41′	17°–32′	17°–23′	17°–14′	17°–6′	16°–58′	16°–50′
	Tooth Depth, In.	2.1229	2.1273	2.1317	2.1362	2.1406	2.1450	2.1494	2.1538	2.1583	2.1627	2.1671	2.1698
50	Center Distance, In.	30.6034	31.0853	31.5672	32.0490	32.5309	33.0128	33.4947	33.9766	34.4584	34.9403	35.4222	35.9020
	Pressure Angle	18°–22′	18°–13′	18°–4′	17°–55′	17°–46′	17°–37′	17°–28′	17°–20′	17°–12′	17°–4′	16°–56′	16°–48′
	Tooth Depth, In.	2.1238	2.1282	2.1325	2.1369	2.1413	2.1457	2.1500	2.1544	2.1588	2.1631	2.1675	2.1701
52	Center Distance, In.	31.6052	32.0870	32.5688	33.0505	33.5323	34.0141	34.4959	34.9777	35.4594	35.9412	36.4230	36.9028
	Pressure Angle	18°–16′	18°–7′	17°–59′	17°–50′	17°–41′	17°–32′	17°–24′	17°–16′	17°–8′	17°–0′	16°–53′	16°–45′
	Tooth Depth, In.	2.1254	2.1298	2.1340	2.1383	2.1426	2.1469	2.1511	2.1554	2.1597	2.1639	2.1682	2.1708

Table XII—Center Distances, Pressure Angles, and Tooth Depths—14½-Deg. Basic Rack, Variable-Center System—1 D. P. Gears (Continued)

No. of Teeth in Gear		Number of Teeth in Pinion											
		10	11	12	13	14	15	16	17	18	19	20	21
54	Center Distance, In.	32.6070	33.0887	33.5704	34.0520	34.5337	35.0154	35.4971	35.9788	36.4604	36.9421	37.4237	37.9035
	Pressure Angle	18°–11′	18°–2′	17°–54′	17°–45′	17°–36′	17°–28′	17°–20′	17°–12′	17°–4′	16°–57′	16°–50′	16°–42′
	Tooth Depth, In.	2.1271	2.1314	2.1355	2.1397	2.1439	2.1481	2.1522	2.1564	2.1606	2.1647	2.1689	2.1715
56	Center Distance, In.	33.6088	34.0904	34.5720	35.0535	35.5351	36.0167	36.4983	36.9799	37.4614	37.9430	38.4245	38.9042
	Pressure Angle	18°–5′	17°–57′	17°–49′	17°–40′	17°–31′	17°–24′	17°–16′	17°–8′	17°–1′	16°–54′	16°–47′	16°–39′
	Tooth Depth, In.	2.1287	2.1329	2.1370	2.1411	2.1452	2.1493	2.1533	2.1574	2.1615	2.1655	2.1696	2.1722
58	Center Distnce, In.	34.6106	35.0921	35.5736	36.0550	36.5365	37.0180	37.4995	37.9809	38.4624	38.9438	39.4252	39.9049
	Pressure Angle	18°–0′	17°–52′	17°–44′	17°–35′	17°–27′	17°–20′	17°–12′	17—5′	16°–58′	16°–51′	16°–44′	16°–36′
	Tooth Depth, In.	2.1304	2.1344	2.1384	2.1424	2.1464	2.1504	2.1544	2.1584	2.1624	2.1663	2.1703	2.1728
60	Center Distance, In.	35.6124	36.0938	36.5751	37.0565	37.5378	38.0192	38.5006	38.9819	39.4633	39.9446	40.4260	40.9056
	Pressure Angle	17°–55′	17°–47′	17°–39′	17°–31′	17°–23′	17°–16′	17°–9′	17°–2′	16°–55′	16°–48′	16°–41′	16°–34′
	Tooth Depth, In.	2.1320	2.1359	2.1398	2.1437	2.1476	2.1515	2.1554	2.1593	2.1632	2.1671	2.1710	2.1734

		22	23	24	25	26	27	28	29	30	31	32	33
22	Center Distance, In.	22.6858											
	Pressure Angle	20°–8′											
	Tooth Depth, In.	2.0734											
23	Center Distance, In.	23.1715	23.6558										
	Pressure Angle	19°–56′	19°–44′										
	Tooth Depth, In.	2.0813	2.0879										
24	Center Distance, In.	23.6558	24.1401	24.6245									
	Pressure Angle	19°–44′	19°–32′	19°–20′									
	Tooth Depth, In.	2.0879	2.0945	2.1011									
25	Center Distance, In.	24.1401	24.6245	25.1088	25.5931								
	Pressure Angle	19°–32′	19°–20′	19°–9′	18°–58′								
	Tooth Depth, In.	2.0945	2.1011	2.1077	2.1143								
26	Center Distance, In.	24.6245	25.1088	25.5931	26.0759	26.5588							
	Pressure Angle	19°–20′	19°–9′	18°–58′	18°–47′	18°–36′							
	Tooth Depth, In.	2.1011	2.1077	2.1143	2.1196	2.1249							
27	Center Distance, In.	25.1088	25.5931	26.0759	26.5588	27.0416	27.5245						
	Pressure Angle	19°–9′	18°–58′	18°–47′	18°–36′	18°–26′	18°–16′						
	Tooth Depth, In.	2.1077	2.1143	2.1196	2.1249	2.1302	2.1354						
28	Center Distance, In.	25.5931	26.0759	26.5588	27.0416	27.5245	28.0073	28.4894					
	Pressure Angle	18°–58′	18°–47′	18°–36′	18°–26′	18°–16′	18°–5′	17°–55′					
	Tooth Depth, In.	2.1143	2.1196	2.1249	2.1302	2.1354	2.1406	2.1452					
29	Center Distance, In.	26.0759	26.5588	27.0416	27.5245	28.0073	28.4894	28.9715	29.4536				
	Pressure Angle	18°–47′	18°–36′	18°–26′	18°–16′	18°–5′	17°–55′	17°–46′	17°–36′				
	Tooth Depth, In.	2.1196	2.1249	2.1302	2.1354	2.1406	2.1452	2.1498	2.1544				
30	Center Distance, In.	26.5588	27.0416	27.5245	28.0073	28.4894	28.9715	29.4536	29.9357	30.4178			
	Pressure Angle	18°–36′	18°–26′	18°–16′	18°–5′	17°–55′	17°–46′	17°–36′	17°–26′	17°–17′			
	Tooth Depth, In.	2.1249	2.1302	2.1354	2.1406	2.1452	2.1498	2.1544	2.1590	2.1635			
31	Center Distance, In.	27.0416	27.5245	28.0073	28.4894	28.9715	29.4536	29.9357	30.4178	30.8986	31.3795		
	Pressure Angle	18°–26′	18°–16′	18°–5′	17°–55′	17°–46′	17°–36′	17°–26′	17°–17′	17°–8′	16°–59′		
	Tooth Depth, In.	2.1302	2.1354	2.1406	2.1452	2.1498	2.1544	2.1590	2.1635	2.1669	2.1703		
32	Center Distance, In.	27.5245	28.0073	28.4894	28.9715	29.4536	29.9357	30.4178	30.8986	31.3795	31.8603	32.3412	
	Pressure Angle	18°–16′	18°–5′	17°–55′	17°–46′	17°–36′	17°–26′	17°–17′	17°–8′	16°–59′	16°–50′	16°–41′	
	Tooth Depth, In.	2.1354	2.1406	2.1452	2.1498	2.1544	2.1590	2.1635	2.1669	2.1703	2.1737	2.1771	
33	Center Distance, In.	28.0073	28.4894	28.9715	29.4536	29.9357	30.4178	30.8986	31.3795	31.8603	32.3412	32.8220	33.3013
	Pressure Angle	18°–5′	17°–55′	17°–46′	17°–36′	17°–26′	17°–17′	17°–'8	16°–59′	16°–50′	16°–41′	16°–32′	16°–23′
	Tooth Depth, In.	2.1406	2.1452	2.1498	2.1544	2.1590	2.1635	2.1669	2.1703	2.1737	2.1771	2.1805	2.1827
34	Center Distance, In.	28.4894	28.9715	29.4536	29.9357	30.4178	30.8986	31.3795	31.8603	32.3412	32.8220	33.3013	33.7806
	Pressure Angle	17°–55′	17°–46′	17°–36′	17°–26′	17°–17′	17°–8′	16°–59′	16°–50′	16°–41′	16°–32′	16°–23′	16°–14′
	Tooth Depth, In.	2.1452	2.1498	2.1544	2.1590	2.1635	2.1669	2.1703	2.1737	2.1771	2.1805	2.1827	2.1849
35	Center Distance, In.	28.9715	29.4536	29.9357	30.4178	30.8986	31.3795	31.8603	32.3412	32.8220	33.3013	33.7806	34.2599
	Pressure Angle	17°–46′	17°–36′	17°–26′	17°–17′	17°–8′	16°–59′	16°–50′	16°–41′	16°–32′	16°–23′	16°–14′	16°–6′
	Tooth Depth, In.	2.1498	2.1544	2.1590	2.1635	2.1669	2.1703	2.1737	2.1771	2.1805	2.1827	2.1849	2.1871
36	Center Distance, In.	29.4536	29.9357	30.4178	30.8986	31.3795	31.8603	32.3412	32.8220	33.3013	33.7806	34.2599	34.7392
	Pressure Angle	17°–36′	17°–26′	17°–17′	17°–8′	16°–59′	16°–50′	16°–41′	16°–32′	16°–23′	16°–14′	16°–6′	15°–58′
	Tooth Depth, In.	2.1544	2.1590	2.1635	2.1669	2.1703	2.1737	2.1771	2.1805	2.1827	2.1849	2.1871	2.1893
37	Center Distance, In.	29.9357	30.4178	30.8986	31.3795	31.8603	32.3412	32.8220	33.3013	33.7806	34.2599	34.7392	35.2185
	Pressure Angle	17°–26′	17°–17′	17°–8′	16°–59′	16°–50′	16°–41′	16°–32′	16°–23′	16°–14′	16°–6′	15°–58′	15°–49′
	Tooth Depth, In.	2.1590	2.1635	2.1669	2.1703	2.1737	2.1771	2.1805	2.1827	2.1849	2.1871	2.1893	2.1915

Table XII—Center Distances, Pressure Angles, and Tooth Depths—14½-Deg. Basic Rack, Variable-Center System—1 D. P. Gears (Continued)

No. of Teeth in Gear		Number of Teeth in Pinion											
		22	23	24	25	26	27	28	29	30	31	32	33
38	Center Distance, In.	30.4178	30.8986	31.3795	31.8603	32.3412	32.8220	33.3013	33.7806	34.2599	34.7392	35.2185	35.6974
	Pressure Angle	17°–17′	17°–8′	16°–59′	16°–50′	16°–41′	16°–32′	16°–23′	16°–14′	16°–6′	15°58′	15°–49′	15°–41′
	Tooth Depth, In.	2.1635	2.1669	2.1703	2.1737	2.1771	2.1805	2.1827	2.1849	2.1871	2.1893	2.1915	2.1928
39	Center Distance, In.	30.8986	31.3795	31.8603	32.3412	32.8220	33.3013	33.7806	34.2599	34.7392	35.2185	35.6974	36.1763
	Pressure Angle	17°–8′	16°–59′	16°–50′	16°–41′	16°–32′	16°–23′	16°–14′	16°–6′	15°–58′	15°–49′	15°–41′	15°–33′
	Tooth Depth, In.	2.1669	2.1703	2.1737	2.1771	2.1805	2.1827	2.1849	2.1871	2.1893	2.1915	2.1928	2.1941
40	Center Distance, In.	31.3795	31.8603	32.3412	32.8220	33.3013	33.7806	34.2599	34.7392	35.2185	35.6974	36.1763	36.6552
	Pressure Angle	16°–59′	16°–50′	16°–41′	16°–32′	16°–23′	16°–14′	16°–6′	15°–58′	15°–49′	15°–41′	15°–33′	15°–25′
	Tooth Depth, In.	2.1703	2.1737	2.1771	2.1805	2.1827	2.1849	2.1871	2.1893	2.1915	2.1928	2.1941	2.1954
41	Center Distance, In.	31.8798	32.3605	32.8413	33.3221	33.8014	34.2807	34.7600	35.2394	35.7187	36.1976	36.6764	37.1553
	Pressure Angle	16°–57′	16°–48′	16°–39′	16°–30′	16°–21′	16°–13′	16°–5′	15°–56′	15°–48′	15°–40′	15°–32′	15°–24′
	Tooth Depth, In.	2.1706	2.1739	2.1772	2.1806	2.1828	2.1850	2.1872	2.1894	2.1917	2.1929	2.1941	2.1954
42	Center Distance, In.	32.3801	32.8607	33.3414	33.8222	34.3015	34.7808	35.2601	35.7396	36.2189	36.6977	37.1765	37.6554
	Pressure Angle	16°–55′	16°–46′	16°–37′	16°–28′	16°–19′	16°–11′	16°–4′	15°–55′	15°–47′	15°–39′	15°–31′	15°–24′
	Tooth Depth, In.	2.1709	2.1741	2.1773	2.1807	2.1829	2.1851	2.1873	2.1896	2.1918	2.1930	2.1942	2.1955
43	Center Distance, In.	32.8804	33.3609	33.8415	34.3223	34.8016	35.2809	35.7602	36.2397	36.7191	37.1978	37.6766	38.1555
	Pressure Angle	16°–53′	16°–44′	16°–35′	16°–26′	16°–17′	16°–10′	16°–2′	15°–54′	15°–46′	15°–39′	15°–31′	15°–23′
	Tooth Depth, In.	2.1712	2.1743	2.1774	2.1808	2.1830	2.1852	2.1874	2.1897	2.1920	2.1931	2.1942	2.1955
44	Center Distance, In.	33.3807	33.8611	34.3416	34.8224	35.3017	35.7810	36.2603	36.7399	37.2193	37.6979	38.1767	38.6556
	Pressure Angle	16°–51′	16°–42′	16°–33′	16°–24′	16°–16′	16°–8′	16°–1′	15°–53′	15°–45′	15°–38′	15°–30′	15°–22′
	Tooth Depth, In.	2.1715	2.1745	2.1775	2.1809	2.1831	2.1853	2.1875	2.1899	2.1921	2.1932	2.1943	2.1956
45	Center Distance, In.	33.8809	34.3612	34.8417	35.3225	35.8018	36.2811	36.7604	37.2400	37.7195	38.1980	38.6768	39.1556
	Pressure Angle	16°–49′	16°–40′	16°–31′	16°–22′	16°–14′	16°–7′	16°–0′	15°–52′	15°–44′	15°–37′	15°–29′	15°–22′
	Tooth Depth, In.	2.1717	2 1747	2.1776	2.1810	2.1832	2.1854	2.1876	2.1900	2.1923	2.1933	2.1943	2.1956
46	Center Distance, In.	34.3811	34.8613	35.3418	35.8226	36.3019	36.7812	37.2605	37.7402	38.2197	38.6981	39.1769	39.6557
	Pressure Angle	16°–47′	16°–38′	16°–29′	16°–20′	16°–13′	16°–5′	15°–58′	15°–51′	15°–43′	15°–36′	15°–28′	15°–21′
	Tooth Depth, In.	2.1719	2.1749	2.1777	2.1811	2.1833	2.1855	2.1877	2.1901	2.1924	2.1934	2.1944	2 1957
47	Center Distance, In.	34.8813	35.3614	35.8419	36.3227	36.8020	37 2813	37.7606	38.2403	38.7199	38.1982	39.6770	40.1558
	Pressure Angle	16°–45′	16°–36′	16°–28′	16°–19′	16°–11′	16°–4′	15°–57′	15°–50′	15°–42′	15°–35′	15°–28′	15°–20′
	Tooth Depth, In.	2.1721	2.1750	2.1778	2.1812	2.1834	2.1856	2.1878	2.1902	2.1926	2.1935	2.1944	2.1957
48	Center Distance, In.	35.3815	35.8615	36.3420	36.8228	37.3021	37 7814	38.2607	38.7405	39.2201	39.6983	40.1771	40.6559
	Pressure Angle	16°–43′	16°–34′	16°–26′	16°–18′	16°–10′	16°–3′	15°–56′	15°–49′	15°–42′	15°–34′	15°–27′	15°–20′
	Tooth Depth, In.	2.1723	2.1751	2.1779	2.1813	2.1835	2.1857	2.1879	2.1903	2.1927	2.1936	2.1945	2.1958
49	Center Distance, In.	35.8817	36.3616	36.8421	37.3229	37.8022	38.2815	38.7608	39.2406	39.7203	40.1984	40.6772	41.1560
	Pressure Angle	16°–41′	16°–33′	16°–25′	16°–17′	16°–9′	16°–2′	15°–55′	15°–48′	15°–41′	15°–33′	15°–26′	15°–19′
	Tooth Depth, In.	2.1725	2.1752	2.1780	2.1814	2.1836	2.1858	2.1880	2.1904	2 1929	2.1937	2.1945	2.1958
50	Center Distance, In.	36.3819	36.8617	37.3422	37.8230	38.3023	38.7816	39.2609	39.7407	40.2205	40.6985	41.1773	41.6561
	Pressure Angle	16°–40′	16°–32′	16°–24′	16°–16′	16°–8′	16°–1′	15°–54′	15°–47′	15°–40′	15°–33′	15°–26′	15°–19′
	Tooth Depth, In.	2.1727	2.1753	2.1781	2.1815	2.1837	2.1859	2.1881	2.1905	2.1930	2.1938	2.1946	2.1959
52	Center Distance, In.	37.3826	37.8624	38.3426	38.8232	39.3025	39.7819	40.2613	40.7411	41.2209	41.6988	42.1776	42.6563
	Pressure Angle	16°–37′	16°–29′	16°–21′	16°–14′	16°–6′	15°–59′	15°–52′	15°–45′	15°–38′	15°–31′	15°–25′	15°–18′
	Tooth Depth, In.	2.1734	2.1759	2.1786	2.1817	2.1839	2.1862	2.1884	2.1908	2.1933	2.1940	2.1949	2.1961
54	Center Distance, In.	38.3833	38.8631	39.3430	39.8233	40.3027	40.7822	41.2618	41.7415	42.2213	42.6991	43.1779	43.6565
	Pressure Angle	16°–34′	16°–26′	16°–19′	16°–12′	16°–4′	15°–57′	15°–50′	15°–43′	15°–36′	15°–30′	15°–24′	15°–17′
	Tooth Depth, In.	2.1740	2.1765	2.1791	2.1819	2 1841	2.1865	2.1888	2.1911	2.1936	2.1943	2.1951	2.1963
56	Center Distance, In.	39.3840	39.8637	40.3433	40.8234	41.3029	41.7825	42.2622	42.7419	43.2216	43.6994	44.1782	44.6567
	Pressure Angle	16°–31′	16°–24′	16°–17′	16°–10′	16°–2′	15°–55′	15°–48′	15°–41′	15°–35′	15°–29′	15°–23′	15°–16′
	Tooth Depth, In.	2.1746	2.1771	2.1795	2.1821	2.1843	2.1867	2.1891	2.1914	2.1939	2.1946	2.1953	2.1965
58	Center Distance, In.	40.3846	40.8643	41.3439	41.8236	42.3032	42.7829	43.2626	43.7423	44.2219	44.6997	45.1786	45.6569
	Pressure Angle	16°–29′	16°–22′	16°–15′	16°–8′	16°–0′	15°–53′	15°–46′	15°–40′	15°–34′	15°–28′	15°–22′	15°–15′
	Tooth Depth, In.	2.1752	2.1777	2.1800	2.1824	2.1847	2.1871	2.1894	2.1917	2.1941	2.1948	2.1955	2.1967
60	Center Distance, In.	41.3852	41.8649	42.3445	42.8241	43.3037	43.7833	44.2630	44.7426	45.2222	45.7000	46.1786	46.6571
	Pressure Angle	16°–27′	16°–20′	16°–13′	16°–6′	15°–59′	15°–52′	15°–45′	15°–39′	15°–33′	15°–27′	15°–21′	15°–15′
	Tooth Depth, In.	2.1758	2.1782	2.1805	2.1828	2.1851	2.1874	2.1897	2.1920	2.1943	2.1950	2.1957	2.1969

		34	35	36	37	38	39	40	41	42	43	44	45
34	Center Distance, In.	34.2599											
	Pressure Angle	16°–6′											
	Tooth Depth, In.	2.1871											
35	Center Distance, In.	34.7342	35.2185										
	Pressure Angle	15°–58′	15°–49′										
	Tooth Depth, In.	2 1893	2.1915										

Table XII—Center Distances, Pressure Angles, and Tooth Depths—14½-Deg. Basic Rack, Variable-Center System—1 D. P. Gears (Continued)

No. of Teeth in Gear		Number of Teeth in Pinion											
		34	35	36	37	38	39	40	41	42	43	44	45
36	Center Distance, In.	35.2185	35.6974	36.1763									
	Pressure Angle	15°–49′	15°–41′	15°–33′									
	Tooth Depth, In.	2.1915	2.1928	2.1941									
37	Center Distance, In.	35.6974	36.1763	36.6552	37.1341								
	Pressure Angle	15°–41′	15°–33′	15°–25′	15°–17′								
	Tooth Depth, In.	2.1928	2.1941	2.1954	2.1967								
38	Center Distance, In.	36.1763	36.6552	37.1341	37.6130	38.0904							
	Pressure Angle	15°–33′	15°–25′	15°–17′	15°–9′	15°–1′							
	Tooth Depth, In.	2.1941	2.1954	2.1967	2.1980	2.1984							
39	Center Distance, In.	36.6552	37.1341	37.6130	38.0904	38.5678	39.0452						
	Pressure Angle	15°–25′	15°–17′	15°–9′	15°–1′	14°–53′	14°–45′						
	Tooth Depth, In.	2.1954	2.1967	2.1980	2.1984	2.1988	2.1992						
40	Center Distance, In.	37.1341	37.6130	38.0904	38.5678	39.0452	39.5226	40.0000					
	Pressure Angle	15°–17′	15°–9′	15°–1′	14°–53′	14°–45′	14°–37′	14°–30′					
	Tooth Depth, In.	2.1967	2.1980	2.1984	2.1988	2.1992	2.1996	2.2000					
41	Center Distance, In.	37.6342	38.1130	38.5904	39.0678	39.5452	40.0226	40.5000	41.0000				
	Pressure Angle	15°–17′	15°–9′	15°–1′	14°–53′	14°–45′	14°–37′	14°–30′	14°–30′				
	Tooth Depth, In.	2.1967	2.1980	2.1984	2.1988	2.1992	2.1996	2.2000	2.2000				
42	Center Distance, In.	38.1342	38.6131	39.0905	39.5678	40.0452	40.5226	41.0000	41.5000	42.0000			
	Pressure Angle	15°–16′	15°–8′	15°–1′	14°–53′	14°–45′	14°–37′	14°–30′	14°–30′	14°–30′			
	Tooth Depth, In.	2.1968	2.1980	2.1984	2.1988	2.1992	2.1996	2.2000	2.2000	2.2000			
43	Center Distance, In.	38.6343	39.1131	39.5905	40.0679	40.5452	41.0226	41.5000	42.0000	42.5000	43.0000		
	Pressure Angle	15°–16′	15°–8′	15°–0′	14°–53′	14°–45′	14°–37′	14°–30′	14°–30′	14°–30′	14°–30′		
	Tooth Depth, In.	2.1969	2.1981	2.1984	2.1988	2.1992	2.1996	2.2000	2.2000	2.2000	2.2000		
44	Center Distance, In.	39.1344	39.6132	40.0906	40.5679	41.0452	41.5226	42.0000	42.5000	43.0000	43.5000	44.0000	
	Pressure Angle	15°–15′	15°–7′	15°–0′	14°–53′	14°–45′	14°–37′	14°–30′	14°–30′	14°–30′	14°–30′	14°–30′	
	Tooth Depth, In.	2.1969	2.1981	2.1985	2.1988	2.1992	2.1996	2.2000	2.2000	2.2000	2.2000	2.2000	
45	Center Distance, In.	39.6344	40.1132	40.5906	41.0679	41.5452	42.0226	42.5000	43.0000	43.5000	44.0000	44.5000	45.0000
	Pressure Angle	15°–15′	15°–7′	15°–0′	14°–52′	14°–45′	14°–37′	14°–30′	14°–30′	14°–30′	14°–30′	14°–30′	14°–30′
	Tooth Depth, In.	2.1970	2.1981	2.1985	2.1988	2.1992	2.1996	2.2000	2.2000	2.2000	2.2000	2.2000	2.2000
46	Center Distance, In.	40.1345	40.6133	41.0906	41.5680	42.0453	42.5226	43.0000	43.5000	44.0000	44.5000	45.0000	45.5000
	Pressure Angle	15°–14′	15°–6′	14°–59′	14°–52′	14°–45′	14°–37′	14°–30′	14°–30′	14°–30′	14°–30′	14°–30′	14°–30′
	Tooth Depth, In.	2.1970	2.1982	2.1985	2.1988	2.1992	2.1996	2.2000	2.2000	2.2000	2.2000	2.2000	2.2000
47	Center Distance, In.	40.6345	41.1133	41.5907	42.0680	42.5453	43.0226	43.5000	44.0000	44.5000	45.0000	45.5000	46.0000
	Pressure Angle	15°–14′	15°–6′	14°–59′	14°–52′	14°–45′	14°–37′	14°–30′	14°–30′	14°–30′	14°–30′	14°–30′	14°–30′
	Tooth Depth, In.	2.1970	2.1982	2.1986	2.1989	2.1992	2.1996	2.2000	2.2000	2.2000	2.2000	2.2000	0 2.200
48	Center Distance, In.	41.1346	41.6134	42.0907	42.5680	43.0453	43.5226	44.0000	44.5000	45.0000	45.5000	46.0000	46.5000
	Pressure Angle	15°–13′	15°–6′	14°–59′	14°–52′	14°–45′	14°–37′	14°–30′	14°–30′	14°–30′	14°–30′	14°–30′	14°–30′
	Tooth Depth, In.	2.1971	2.1982	2.1986	2.1989	2.1992	2.1996	2.2000	2.2000	2.2000	2.2000	2.2000	2.2000
49	Center Distance, In.	41.6347	42.1134	42.5907	43.0681	43.5453	44.0226	44.5000	45.0000	45.5000	46.0000	46.5000	46.5000
	Pressure Angle	15°–13′	15°–5′	14°–58	14°–52′	14°–45′	14°37–′	14°–30′	14°–30′	14°–30′	14°–30′	14°–30′	14°–30′
	Tooth Depth, In.	2.1971	2.1983	2.1986	2.1989	2.1992	2.1996	2.2000	2.2000	2.2000	2.2000	2.2000	2.2000
50	Center Distance, In.	42.1347	42.6135	43.0908	43.5681	44.0454	44.5226	45.0000	45.5000	46.0000	46.5000	47.0000	47.5000
	Pressure Angle	15°–12′	15°–5′	14°–58′	14°–51′	14°–44′	14°–37′	14°–30′	14°–30′	14°–30′	14°–30′	14°–30′	14°–30′
	Tooth Depth, In.	2.1971	2.1983	2.1986	2.1989	2.1992	2.1996	2.2000	2.2000	2.2000	2.2000	2.2000	2.2000
52	Center Distance, In.	43.1349	43.6137	44.0909	44.5682	45.0454	45.5226	46.0000	46.5000	47.0000	47.5000	48.0000	48.5000
	Pressure Angle	15°–11′	15°–5′	14°–58′	14°–51′	14°–44′	14°–37′	14°–30′	14°–30′	14°–30′	14°–30′	14°–30′	14°–30′
	Tooth Depth, In.	2.1973	2.1984	2.1987	2.1990	2.1993	2.1996	2.2000	2.2000	2.2000	2.2000	2.2000	2.2000
54	Center Distance, In.	44.1351	44.6139	45.0910	45.5682	46.0454	46.5226	47.0000	47.5000	48.0000	48.5000	49.0000	49.5000
	Pressure Angle	15°–11′	15°–4′	14°–57′	14°–50′	14°–44′	14°–37′	14°–30′	14°–30′	14°–30′	14°–30′	14°–30′	14°–30′
	Tooth Depth, In.	2.1975	2.1985	2.1988	2.1991	2.1993	2.1996	2.2000	2.2000	2.2000	2.2000	2.2000	2.2000
56	Center Distance, In.	45.1353	45.6140	46.0911	46.5683	47.0454	47.5226	48.0000	48.5000	49.0000	49.5000	50.0000	50.5000
	Pressure Angle	15°–10′	15°–4′	14°–57′	14°–50′	14°–43′	14°–37′	14°–30′	14°–30′	14°–30′	14°–30′	14°–30′	14°–30′
	Tooth Depth, In.	2.1977	2.1986	2.1989	2.1991	2.1993	2.1996	2.2000	2.2000	2.2000	2.2000	2.2000	2.2000
58	Center Distance, In.	46.1355	46.6140	47.0912	47.5683	48.0455	48.5226	49.0000	49.5000	50.0000	50.5000	51.0000	51.5000
	Pressure Angle	15°–10′	15°–3′	14°–56′	14°–49′	14°–43′	14°–37′	14°–30′	14°–30′	14°–30′	14°–30′	14°–30′	14°–30′
	Tooth Depth, In.	2.1979	2.1987	2.1990	2.1992	2.1994	2.1996	2.2000	2.2000	2.2000	2.2000	2.2000	2.2000
60	Center Distance, In.	47.1356	47.6140	48.0912	48.5684	49.0455	49.5226	50.0000	50.5000	51.0000	51.5000	52.0000	52.5000
	Pressure Angle	15°–9′	15°–3′	14°–56′	14°–49′	14°–42′	14°–36′	14°–30′	14°–30′	14°–30′	14°–30′	14°–30′	14°–30′
	Tooth Depth, In.	2.1980	2.1988	2.1990	2.1992	2.1994	2.1996	2.2000	2.2000	2.2000	2.2000	2.2000	2.2000

pair of gears. We have from equation (58) in the eighth article

$$\text{Number of teeth in contact} = \frac{\sqrt{E_1^2 - a_1^2} + \sqrt{E_2^2 - a_2^2} - C \sin \alpha}{Pn}$$

Where $E_1 = 6.6009$ in.
$a_1 = 4.8407$ in.
$E_2 = 20.9143$ in.
$a_2 = 19.3629$ in.
$C = 25.5931$ in.
$\alpha = 18° 58'$
$\sqrt{E_1^2 - a_1^2} = 4.4876$
$\sqrt{E_2^2 - a_2^2} = 7.9046$
$C \sin \alpha = 8.3183$
$Pn = 3.0415$ in.

Whence contact = 1.339 tooth intervals.

With favorable sliding conditions, this contact should be sufficient for the transmission of power. We will therefore examine these sliding conditions. We have from the sixth article

$$\text{Specific sliding on pinion} = \frac{b_2 N_2 - b_2 N_1}{b_1 N_2}$$

$$\text{Specific sliding on gear} = \frac{b_2 N_1 - b_1 N_2}{b_2 N_1}$$

Where b_1 and b_2 are the lengths of the generating lines at the point of contact of the pinion and gear respectively.

The active profiles of both of these gears extend to the tips of their teeth, whence the maximum radii of curvature of the active profiles are equal to $\sqrt{E^2 - a^2}$, or 4.4876 in. on the pinion and 7.9046 in. on the gear. By subtracting these figures from the total length of the line of action, we get 0.4137 in. as the minimum radius of curvature of the active profile of the pinion and 3.8307 in. for the gear. Thus at the beginning of contact we have

$b_1 = 0.4137$ in.
$b_2 = 7.9046$ in.
$N_1 = 10$ teeth
$N_2 = 40$ teeth

$$\text{Specific sliding on pinion} = \frac{0.4137 \times 40 - 7.9046 \times 10}{0.4137 \times 40} = -3.84$$

$$\text{Specific sliding on gear} = \frac{7.9046 \times 10 - 0.4137 \times 40}{7.9046 \times 10} = +0.79$$

And at the end of contact we have

$b_1 = 4.4876$ in.
$b_2 = 3.8307$ in.

$$\text{Specific sliding on pinion} = \frac{4.4876 \times 40 - 3.8307 \times 10}{4.4876 \times 40} = +0.78$$

$$\text{Specific sliding on gear} = \frac{3.8307 \times 10 - 4.4876 \times 40}{3.8307 \times 10} = -3.68$$

These specific sliding conditions are very favorable and are plotted in Fig. 72. It will be noted that these sliding conditions are very similar on both the gear and the pinion, whereas on a pair of gears of standard form with unequal tooth numbers, the sliding conditions on the pinion are much worse than those on the gear. The nature of the sliding action itself is probably of secondary importance and has but little effect on the action of the gears. The great value of determining this specific sliding lies in the fact that it indicates very clearly the sensitiveness of the active tooth profiles. When the graph of specific sliding has a sharp bend, sensitive tooth profiles are involved, the proper production of which is always difficult. The gears with the greatest specific sliding will always be the most troublesome ones in production. When these specific sliding conditions are balanced, as in this example, it indicates that the degree of care required in production is about the same for both.

After we have established the largest and the smallest gear of the series with variable tooth proportions, the next step is to establish the intermediate sizes; that is, the gears with more than ten and less than forty teeth. We will make all of these gears with a constant root radius, and change only their tooth depths to suit the conditions that exist as they are intermeshed among themselves.

The root of the 10-tooth pinion is at the undercut limit, while that of the 40-tooth gear is well outside of

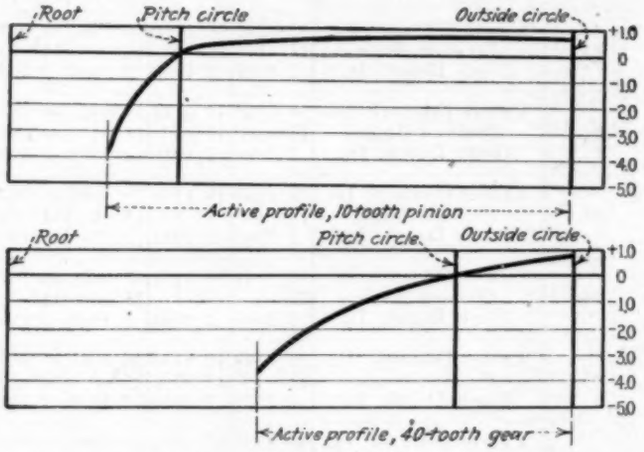


Fig. 72—Specific sliding between a 10-tooth pinion and a 40-tooth gear, 14½-deg. variable center system

it. The simplest method of establishing the intermediate gears would be to make their root radii proportionately larger as their tooth numbers increase, by dividing the difference between the root radius of the 10-tooth pinion and the root radius of the 40-tooth gear by the number of intervals between them, and adding this increment to the root radius of the 10-tooth pinion to obtain that of the 11-tooth pinion, and so on until the series is completed.

This has been done, and the results are given in Table XI, together with other data, such as radii of base circles, radii to undercut limit, tooth thickness at the 14½-deg. pitch line, that are useful in different gear computations.

The various equations in previous articles enable the pressure angles and the center distances for any combination of these gears to be computed. The tooth depths would be established as shown in the preceding article. Table XII gives the center distances, pressure angles, and tooth depths for pinions of ten to forty-five teeth meshing with other gears or pinions of from ten to one hundred teeth. It will be noted that for pinions of forty teeth and larger, the tooth depth is constant and the center distances are proportional to the numbers of teeth. These tables are based on a basic rack of 1 diametral pitch. For other

diametral pitches, the values given should be divided by the pitch used.

The two foregoing tables enable the dimensions for any pair or train of meshing gears to be determined by simply adding the proper tooth depth to the root radii of the selected combination of gears to obtain the outside radii, while all other dimensions are taken directly from the tables.

As an example, we will take a 20-tooth pinion that is to mesh with a 35-tooth gear. We get from the Table XI

Number of teeth	20	35
Root radius	9.2577 in.	16.4144 in.

And from Table XII

Center distance	28.0073 in.
Pressure angle	18° 5′
Tooth depth	2.1406 in.

Whence, outside radius of pinion

$$= 9.2577 + 2.1406 = 11.3983 \text{ in.}$$

Outside radius of gear

$$= 16.4144 + 2.1406 = 18.5550 \text{ in.}$$

A study of Table XII will show that all combinations of gears with tooth numbers between ten and forty, whose sum of tooth numbers is the same, will have the same center distance, pressure angle, and tooth depth. For example, the 10-40 combination, the 11-39 combination, the 12-38 combination, etc., all have a center distance of 25.5931 in., a pressure angle of 18° 58′, and a tooth depth of 2.1143 in. Thus gear sets of several different ratios, the total number of teeth in each pair being the same, will run on a fixed pair of shafts, such as are used in change gear boxes. They can also be used as change gears, where the centers are adjusted to suit the particular gears selected. Although the smaller gears of this series do not operate on proportional center distances, they are all interchangeable with each other and can be used as extensively as the conventional systems, provided the center distances are established to suit this series.

New Use for Bakelite

Surveying instruments equipped with thumbnuts, eyepieces, and tangent and clamp screwheads that are not affected by heat or cold have just been perfected.

This development in the manufacture of surveying instruments has come about as the result of the increasing range of surveying activities throughout the world. Surveyors have encountered difficulties in working under the extremes of Arctic or Tropical temperatures, for in regions where the thermometer is 40 or 50 deg. below zero, or 100 deg. above, it is very difficult to set adjustments accurately by using the bare hands.

The equipment on the newer instruments is designed to do away with this problem by supplanting metal adjustment parts, and to allow surveyors to handle the adjusting of their instruments in any degree of temperature without inconvenience. Bakelite molded is the material used, and is said to be superior for this purpose to ivory, which has been utilized in some cases.

Owing to the special qualities of the molded product, permitting simplified production, manufacturers have been able to eliminate from nine to thirty-two manufacturing operations on the parts concerned, as well as to reduce the cost of production by two-fifths.

Co-operative Vocational Education in Lewistown Schools

By Ralph L. Jacobs
Director of Vocational Education

A CO-OPERATIVE, part-time course in schooling and shop practice of the machinist trade is being conducted by the vocational department of the public schools of Lewistown, Pa., and the large repair shop of the Standard Steel Works Co., Burnham, Pa., under the guidance of the director of vocational education. Both State and Federal financial aid is furnished the school. The plan is to have a selected group of student-apprentices spend alternate weeks in the shop, working ten hours each day, and in the school, working six hours a day.

The boys that are enrolled in these student-apprentice groups are carefully selected by means of a series of tests and studies that have been recommended by leaders in the field of educational psychology and sociology. The material gathered by industry and by departments of research in graduate schools of education is being used in the work of advising the boys as to their possible chances for success in their respective choices of life work, whether it be a trade, business, or professional calling. Since the Lewistown schools have no shop equipment of their own with which they could make try-outs in the trades common to the locality, these objective tests and a two-month's trial period in industry are used as a means of selecting the students.

A single foreman-instructor remains with the same group during the entire period of apprenticeship. While in the shop the boys are under the direct guadance of this instructor. They also receive orders from the master mechanic, and the foreman and assistant foreman of the particular department they are in. Indirectly they are also under the guidance of the plant engineer and the employment manager, all of the Standard Steel Works Co. When in school the following week the apprentices are given instruction in mathematics, science and drawing by their shop instructor. He correlates this theory with the specific shop practice of the preceding week. Other teachers give instruction in English and history. Industrial history has been substituted for ancient history for the machinist group, however, and in presenting both these subjects the traditional textbook has been discarded in favor of a number of books by modern authorities on each subject.

Even in such a selected group, individual differences are recognized. One method of accomplishing this aim is by means of a weekly contract form which is given to every apprentice on Monday morning and tells him the work that must be completed during the week spent in school. If this work is successfully completed in advance of the allotted time, the student may read technical magazines; otherwise he must report Saturday morning to finish it. Individual records of the work done by each apprentice during his week in the shop are kept also in the form of a diary. The apprentice fills out the form, giving the time spent on each job, a description of it, and a sketch of the piece. From these reports it is possible to conduct general discussions on shop topics during the ensuing week, beside keeping a check on the practical work given each boy in any given period.

Book Reviews

Corrosion—Causes and Prevention, an engineering problem. By Frank N. Speller, Director of Metallurgical Department, National Tube Co. Six hundred and twenty-one pages, 6x9 in., cloth. Indexed. Published by the McGraw-Hill Book Co. Inc., 370 Seventh Ave., New York. Price $6.

This book is an inventory of available material on corrosion with particular reference to the ferrous metals. It is divided into two parts: general principles and preventive measures. In the first part the theory of corrosion is discussed, and both a popular and a technical discussion of the accepted Electrochemical Theory is given. The influence of all known factors is analyzed: methods of manufacture and treatment; composition; and external factors such as moisture, temperature, and dissolved substances in the corroding solution. Various methods of corrosion testing are described together with the relative results obtained on ferrous metals.

In the second part will be found a discussion of the practical application of the facts and principles already established with reference to conditions found in air, under water, underground, in closed water systems, in steam boilers, in the chemical industries, and in other situations. Usually the solution of the problem lies in the choice of using a more durable metal or a protective coating, but in certain cases recourse must be had to conditioning the water to form a protective coating.

A selected and annotated bibliography is given that supplements the four hundred references in the text. Added to this is a subject and author index. The arrangement of the text, together with these lists, makes this book a practical handbook for the engineer.

S. A. E. Handbook, March, 1926. Six hundred pages, 4¼x7¼ in. Published by the Society of Automotive Engineers, Inc., New York. Price to non-members $5.00.

This volume marks the passing of the loose-leaf S.A.E. handbook which is discontinued and in its place the handbook is to be revised and reprinted semi-annually. The former method of numbering, by sectional letters and pages is followed as before and both contents and index pages are provided.

Employee Representation. By Ernest Richmond Burton, Supervisor of Research, Bureau of Personnel Administration, New York City. Two hundred eighty-three pages, 5⅜x8 in., cloth boards. Indexed. Published by The Williams & Wilkins Co., Baltimore, Md. Price $3.00.

This book is the fifth in the "Human Relations Series," and is an intensive review of the employee representation movement in industrial organizations. The author has devoted much time over a period of years to the study of the representation plans now in existence, and in his book has reviewed the history of works councils, together with the objects, difficulties, and policies. He indicates that the earlier advocates of scientific management under Taylor were not economists, and ignored the human problems, making their appeals only through the wage motive.

The author has tried to show how men are brought to enjoy their work by being given the opportunity of self-expression. The book is divided into fifteen chapters, taking up the whole subject systematically. The chapter on the sources of modern industrial conflicts should be read by every employer of men. Six chapters are devoted to the methods of organization and procedure, with practical examples taken from existing plans. Methods of administration, and the balancing of results, are then taken up in detail. The book should be valuable to any executive desiring concise information on this important subject.

Cost Accounting for Sales. By Dr. Joseph R. Hilgert, of the College of Commerce, University of Illinois. Two hundred fifty-nine pages, 6x8½ in. Cloth. Indexed. Illustrated with tables and forms. Published by The Ronald Press Company, New York. Price $4.50.

This is a book intended for sales executives, or for any manufacturer having a product that must be sold in a competitive market. The author starts out on the assumption that profits today depend to a large extent on the control of selling cost, and that the problem is not how to produce, but "how and where to sell at a profit."

The author has divided his subject into 15 comprehensive chapters, and has grouped his material in textbook form, making it convenient for study and reference. In the first two chapters the functions of marketing and sales organizations as they exist today are taken up with specific examples, and the principles of control are explained.

The types of sales organizations are treated systematically, and comparative studies are made of methods of classification of sales expenses and of costs of selling. Sales quotas and budgets are covered in a separate chapter, and considerable space is given to the subject of evaluation of sales territories. Typical sales records and reports are shown, and a chapter is given over to the discussion of effective compensation for salesmen.

Blacksmithing. By R. W. Selvidge, Professor of Industrial Education, and J. M. Allton, Instructor in Forging, University of Missouri. One hundred fifty-six pages, 6x9 in., one hundred five illustrations, cloth-board cover. Published by the Manual Arts Press, Peoria, Ill. Price $1.20.

This book is designed for use as a text in school and farm shops, and for the blacksmith who is interested in extending his knowledge and increasing his skill. The material, arranged to offer flexibility in teaching the subjects, gives a comprehensive analysis of blacksmithing, based on what one must be able to do to be proficient in the trade. In an introductory chapter, suggestions are given for the use of the manual in which the result of tests in various grades of advancement are shown.

The instructions cover operations involved in forging and welding of iron and steel, hardening and tempering, soldering, general repair work, tire setting and horseshoeing. The directions show, step by step, how to perform each operation. Standard tables, showing weights of steel, wire-gage sizes and various screw standards, are included.

Machining Valve Seats in an Aeronautical Engine

By George A. Tilsher
Tool Engineer, Wright Aeronautical Corporation

Several interesting features are involved in the design of the tools for each operation—A single fixture and one machine unit suffices

IN AN aviation engine all parts that are subject to wear should be easily replaceable with a minimum amount of scrap material left over. An example of such a part is the valve seat in the cylinder head. The seat is an inserted part. Here, aside from the foregoing, a second factor also enters in that the material of the cylinder head has not all the desirable properties that would suit it for valve service. The Wright Aeronautical Corporation, for example, use an aluminum alloy cylinder head, while the inserted valve seat is made of hard alloy bronze.

Since there are some interesting features involved in the preparation of the head for the valve insert, the insertion of the piece itself and the subsequent machining operations, the procedure will be described in some detail. In Fig. 1 is shown a cross-section of the cylinder head together with the valve seat before and after it is inserted in the head. At *A* the head has been bored out to receive the seat; at *B* the seat has been inserted and spun into its locked position; while at *C* the valve seat proper is shown. The dimensions on the figure are base dimensions, but an actual production drawing would also indicate suitable tolerances.

The cylinder head is an aluminum alloy casting of high tensile strength. The tools used to cut this metal are made of high-grade tool steel and the speeds and feeds are such as would be used for cutting cast iron. One important difference should be noted, however: while cast iron may be cut dry, it is essential in the case under discussion to flood the tool with kerosene oil under sufficient pressure to wash away the chips as fast as they are formed. This cleansing is the determining factor rather than any cooling action, as otherwise a smooth machined surface could not be obtained.

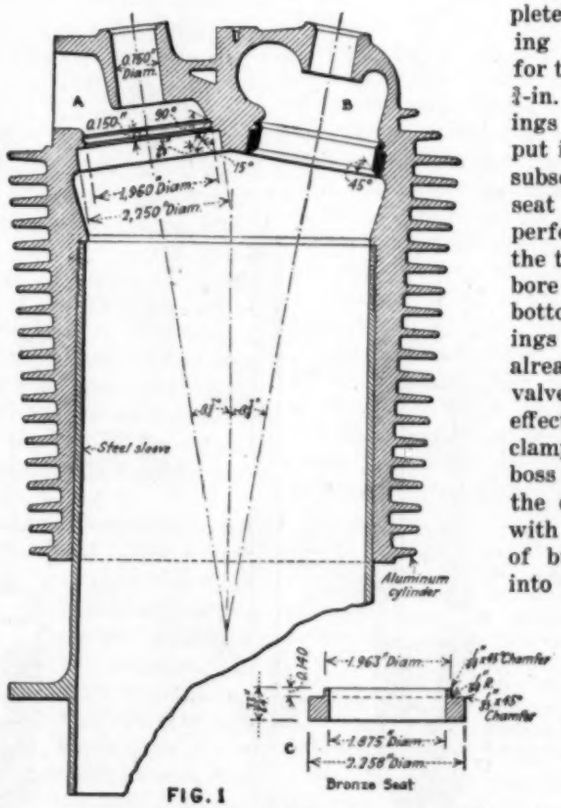


Fig. 1—Cylinder head of an air-cooled aeronautical engine

The alloy bronze valve seat is also machined with high-carbon tools since the metal is quite hard. For the same reason a very sharp edge is avoided at the cutting point of the tool and the land behind the edge is narrow; without these features there is a tendency for the tool to heat excessively. A steady pressure must also be applied to obtain a true finished surface. Absolute accuracy and smooth surfaces are essential for the performance of an aeronautical air-cooled engine.

The cylinder head is first completely finished on the inside, including the dome, the thread is cut for the steel cylinder sleeve, and the ¾-in. holes for the valve-stem bushings are drilled. The head is then put in the fixture, Fig. 2, where all subsequent operations on the valve seat and the valve-seat insert are performed. The head is located at the top by a plug *D*, that fits in the bore of the open end, and at the bottom by two hollow pins or bushings *A* that engage the ¾-in. holes already drilled in the piece for the valve-stem bushings. Locking is effected by the hand screw *C*, which clamps the piece at a center drilled boss provided for this purpose on the casting. A fixed pin engages with a spiral groove cut in the head of bushing *A*, which is advanced into the piece and locked in place when it is rotated by hand. The displaced section *NN* shows this construction.

The axis of each valve seat is inclined at an angle of 8¾ deg. to the axis of the cylinder and, in order to alternately swing these axes into a vertical position so that an ordinary upright drill press may be used, the fixture carrying the cylinder head is supported by trunnions at *H*. The proper angle is maintained by a spring-set plunger *F* in the frame that engages with either of two drilled and bushed holes in the fixture for locating the inlet- and exhaust-valve axes respectively. The guide bushing *G* is similarly mounted in

Trunion Fixture and Tools for Machining Valve Seats in an Air-Cooled Aeronautical Engine

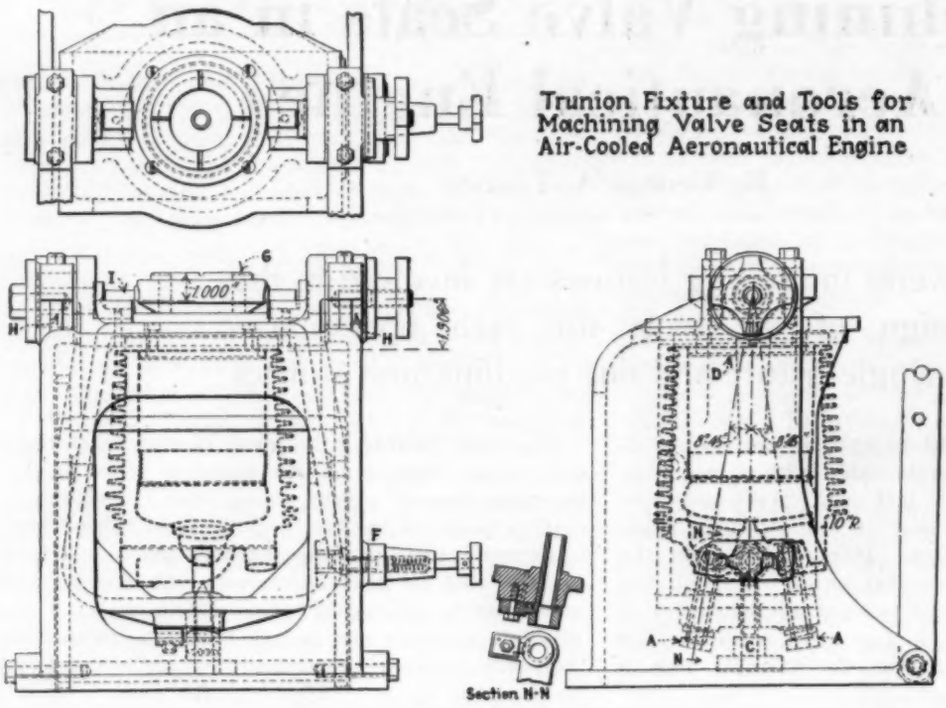


FIG. 2

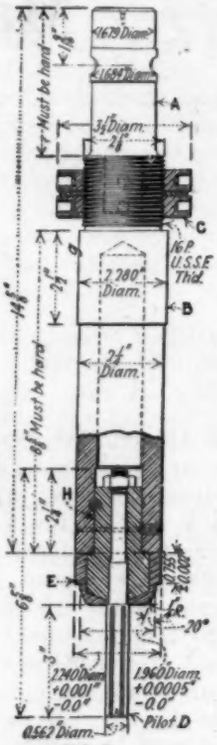


FIG. 3

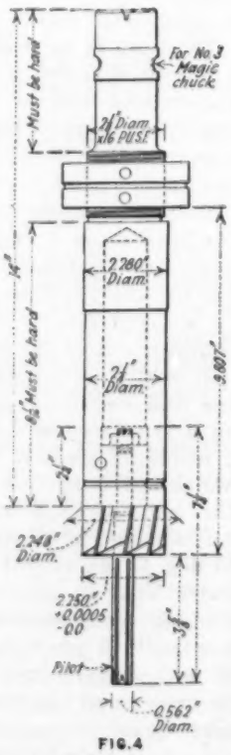


FIG. 4

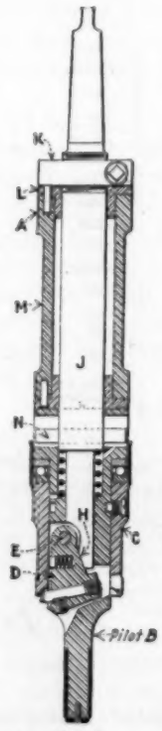


FIG. 5

FIG. 6

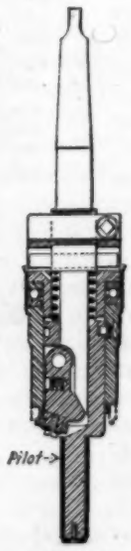


FIG. 7

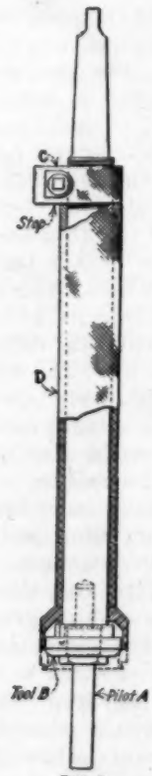


FIG. 8

trunnions *I* so that its face will always remain horizontal regardless of the angle of the fixture. This bushing is accurately ground in its bore and its upper face must be located within a very small tolerance since the tools are located from this surface for their correct cutting depth. Also a flush-pin depth gage is used to check these depths from this point.

The fixture is loaded by swinging it into a horizontal position.

The first operation on the valve seat in the head is a roughing one. The tool is shown in Fig. 3. Shank *A* fits into a No. 3 Magic chuck which, in turn, is held in the upright drill spindle. Ground surface *B* has a running fit in the upper guide bushing of the fixture (*G* in Fig. 2). The nut, washer, and lock washer assembly *C*, is adjusted to get the correct depth of cut, the lower nut acting as a stop. Further guiding of the tool is obtained by the pilot *D* which fits into the locating jig bushing in the valve steam holes (*A* in Fig. 2). Tool *E* is the circular, fluted type and is pressed on the part *H* which is locked in the main tool sleeve by suitable pins. This construction is clearly shown. The spindle and tool are advanced by hand.

Finish boring of the seat is accomplished by the tool shown in Fig. 4, which is so similar to the tool just described that further amplification is unnecessary. The cutter details should be noted, however, particularly the narrow lands.

The tool used to form the 15-deg. anchor angle is interesting from a design point of view. It is shown in Fig. 5. The taper shank fits directly into the drill spindle, and hence no chuck is required. As with the other tools, guiding takes place at top and bottom, at ground surfaces *A* and *B* respectively. The tool body *C* rests in the seat previously bored and does not revolve. A ball thrust bearing separates it from the aluminum sleeve *M*, which is driven positively by the pin *N*, which in turn is free to slide up and down in a slot for a limited distance. The tool holder *D* pivots at *E* and is actuated by the cam surface *H* on the stub end of the main spindle *J*. The movement of the tool is stopped (through the train just described) by the stop collar *K* when it strikes the hardened steel plate *L* on the top of the sleeve. The large helical spring tends to keep the pin *N* at the top of its slot, while a small spring, actuating a round-head pin, holds the tool carrier against the cam.

The next step is to insert the valve seats proper and to finish machine them in place. The head is first heated in a muffle furnace to 800 deg. F. and then the valve seats are dropped in place. The steel cylinder sleeves are also screwed in at this time. In order to obtain a shrink fit, or, in fact, to put in the seats at all, quick action is necessary to get the pieces in place before they heat up and expand. For this purpose the tool shown in Fig. 6, was designed. Three pins *A* are controlled by the collet arrangement, which is actuated by the helical spring at the top of the tube and released by pressure on button *B*. The pins are forced out against the inner surface of the valve seat, and a circular wire spring *C* furnishes the reaction when the cone is withdrawn. Note the snub nose of the pilot to facilitate its insertion in the mating bushing.

The lip on the seat is next spun over the 15-deg. anchor angle by means of the tool shown in Fig. 7. The construction of this unit is very similar to the tool shown in Fig. 5, except that a roller is now substituted for the cutting tool. Because the steel cylinder sleeve is now in place no upper guide bushing can be used; the work is placed in the same jib and fixture, Fig. 2, as before, however.

The final operation is to form the 45-deg. angle on the valve seat proper. This is accomplished with the tool shown in Fig. 8. The pilot *A* fits in the valve stem bushing as in previous operations and its shank also functions as a locking piece for the tool *B* which is the circular, fluted type. Sleeve *D* is stationary and rests upon the seat. The tool is advanced by hand until stop *C* strikes the top of the stationary sleeve.

Although six different tools are used in performing all the operations described, only one fixture and one machine, an upright drill press are used. With a little ingenuity, perhaps, some of these tools might be combined, but with a fair production rate the time consumed by each operation is reasonably short and the time lost in changing tools is quite negligible.

The Design and Manufacture of Hypoid Gears—Discussion

By Arthur L. Stewart
Gleason Works, Rochester, N. Y.

The name of Nikola Trbojevich was mentioned in the above paper published on page 857, Vol. 64, of the *American Machinist*, and due credit should be given him for the important work that he did. In patents already issued or now pending he used new methods of analysis that were of material assistance in the first steps of the work that was done at the Gleason Works. He also discovered new forms of gears of the general curved-tooth hypoid class.

A more extended reference to Mr. Trbojevich's work is not necessary as we are all familiar with the articles published in *Machinery* and *American Machinist*, Vol. 59, page 647, in November, 1923, describing his work in hobbing spiral bevel gears and including the curved tooth gears of the hypoid class that he had developed.

The developments at the Gleason Works are the work of Ernest Wildhaber, research engineer and co-author of the paper under discussion.

Several important steps had to be made by Mr. Wildhaber before the present development could be offered in practical form.

1—The solution of the mesh between curved pitch lines had to be made general where it had previously been made for only one specific case.

2—Circular arcs were used in place of various more complicated curves. A simple and quite essential method of determining radii of curvature was originated.

3—The solution of the mesh between curved pitch lines was extended to two tapered gears. In other words, the problem was analyzed in three dimensions instead of two only, as had been formerly done. Obviously this problem cannot be solved by the use of developments in a plane.

The important feature of the present disclosure is that for the first time there is offered a system of curved-tooth hypoid gears having generated profiles along with a highly practical and commercial method of producing them.

This statement is made in order to give proper credit to each inventor. It is unnecessary, as far as the patent situation is concerned, since all of the issued and pending patents of Mr. Trbojevich having to do with the hypoid development as well as those covering hobbing spiral bevel gears, are owned by the Gleason Works.

THE · FOREMAN'S · ROUND · TABLE

How Should Suggestions Be Handled?

The following narrative is a "case" presentation of the topic. It has been written to involve some of the questions that arise in the average shop. For guidance in preparing discussion the questions at the foot of the page have been prepared

AL AND ED, foremen of the planer and grinder departments, sat in their favorite seat in the front end of the smoker, on the 5:05 rattler, homeward bound.

"I saw Scotty going over some drawings with the super today, Al. Some stand in, Scotty's got. What's he trying to do, beat you out of your job?"

"No, I knew all about it. Fact is, I sent him to Williams. I think he's got the right scheme on that Pulitzer job. If it works out as well as Scotty thinks, the firm'll make a barrel of money on that job."

"Yes, and the next thing you know, you'll be looking for a job, and Scotty'll be foreman."

"Maybe so, Ed, but what else could I do? Keep Scotty away from Williams and the profit away from the firm?"

"You know as well as I do, Al, that the foreman is responsible for the showing of his department. Why didn't you pass Scotty's idea on to Williams? Look at Fred, stands ace-high, and every one of his cost-cutters came from his men."

"I don't think all of 'em did, but most of 'em at that, I guess. But I happen to know that when Fred passes on an idea he labels it with the name of the man that thought of it. If he didn't and Williams found it out, good-night Fred. You can't fool Williams long, either. Besides, the way I look at it, it's not necessary for the foreman to have all the ideas. It's up to him to see that the work gets out and that the men are satisfied. If his men get ideas, Williams is big enough to give him credit for picking good ones."

"I don't look at it that way, Al—or anyway I haven't been. Haven't had much to do with Williams. With the old super, though, before Williams came, and before you came, everything had to come through the foremen. He wouldn't deal direct with the men. And about 100 per cent of the foremen took all the credit. Guess that's where I get my ideas. Maybe you're right, and maybe Williams is right, I don't know. I want to do what's right, even if some better guy does get my job.

"Fact is, I wish we had foremen's meetings or something, so's we could talk things like this over. If Williams is all you seem to think, maybe he'll start 'em. You seem to be on his good side. Why don't you ask him, Al?"

Was Al right in sending Scotty to Williams? Or should he have done as Ed would have done? Or should some entirely different scheme be used? Should suggestions be passed on through the foremen? Was the old superintendent right in refusing to deal directly with the men?

Is Al in danger of losing his job to Scotty? Should Scotty be encouraged for his idea? If so, how? Or has Scotty done only what is expected as a part of his job? Is Williams likely to favor the suggestion of foremen's meetings? Should he or should he not, and why?

All foremen are urged to discuss these questions. Acceptable letters will be paid for. The discussion is not limited to foremen, of course.

THE · FOREMAN'S · ROUND · TABLE

SIGNS are multiplying that the foreman is about to come into his own, at least so far as recognition of the importance of his position in the industrial scheme is concerned. Apparently the day when the most skillful workman in a gang was called in at quitting time and informed that he would start in as a foreman the next morning is drawing to a close. Many extremely able foremen have been developed by this sink-or-swim policy but nobody has any conception of the amount of money they wasted or the discontent they aroused among their men until they learned how to be foremen. How much easier it would have been for them, how much less expensive for their companies, how much better for their men, had they been given some instruction in the handling of men, in the direction of work and in the many other activities that enter into the foreman's daily job.

For some years the most progressive of industrial concerns have realized the vital importance of carefully thought out foreman training and they have profited accordingly. Today there are few companies employing any number of foremen that do not hold at least occasional foremen's meetings to discuss problems of mutual interest. But there are still very few in which there is a definite policy looking to the training of foremen for their very important work.

It is encouraging to note that such bodies as the Chamber of Commerce of the United States and the National Metal Trades Association are giving careful attention to the subject and doing all they can to stimulate interest. Good work is also being done by the Federal Board for Vocational Education and by certain state boards. The foremen's club idea is another movement that merits commendation.

There are well-organized courses for foremen conducted by colleges, schools and business organizations that specialize in training work. And there are company courses. All of these efforts to train foremen are laudable and they are variously successful.

Sensing the need for material to be used in certain types of foreman training work and believing that a real contribution could be made through their efforts the editors of the *American Machinist* have been studying the question for a number of months. Several different treatments of the proposed subject matter have been discussed but the final choice fell to what is generally known as the "case method" of presenting the chosen topic. The first insertion of "The Foreman's Round Table" appears on the opposite page. The editors will welcome criticism of the subject matter, method of presentation, and arrangement as it is their aim to present material that will be useful to the superintendent or manager who conducts a periodical foremen's conference as well as to the individual foreman.

To carry out the idea of presenting subjects in such form that they can be treated by the conference method, each case is followed up by a number of specific questions that should serve to open up discussion. In addition, the topic for the following issue will be boxed on this page each week, as is done here, and will be supplemented by several rather general questions bearing upon it. It is hoped that the questions will lead to written comments that can be published in later issues thus keeping this section a live part of the paper and a clearing house for opinions on the various subjects brought up for discussion. Space rates will be paid for acceptable letters and they will be published on the right hand page (this one) insofar as space permits.

THE · NEXT · TOPIC

How much standby equipment?

When is standby equipment justified?

What is a reasonable amount to have available?

What precautions should the foreman take if he is short of standby equipment?

How much should the foreman know about the urgency of delivery on every job?

In presenting this new department it is not the intention to enter into competition with any of the existing types of foreman training service. For this reason no attempt at the logical continuity of a course will be made in arranging the subjects to be taken up. It is rather the purpose to supply topics that can be taken up by foreman conferences as a supplement to the regular instructional material provided by company or commercial courses.

Ed and Al with their contrasting viewpoints are two real foremen although they don't go by those names in the shop where they work. They have a number of topics important to foremen to discuss and they are quite open-minded when it comes to discussing any particular problem you would like to refer to them. All you have to do to suggest a topic is to send in a letter about it to the editor of "The Foreman's Round Table." He will put it up to Ed and Al.

Discussion

In future issues this page, facing "The Foreman's Round Table," will be devoted to discussions of any of the questions put forward in earlier round tables. As stated at the foot of the opposite page discussions that can be used will be paid for.

If you are moved to express your opinion on any of the topics discussed, as it is hoped you will be, please make the statement of your ideas or experience as concise and to the point as possible because space is limited. A pen name will be used if you prefer to keep your own name out of the paper.

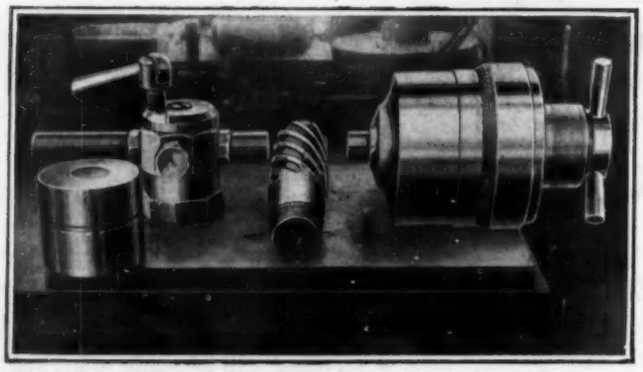
Ideas from Practical Men

The department, "Ideas from Practical Men," is devoted to the exchange of information on methods useful to the machinery industries. Its scope includes all divisions of the machine building industry, from drafting room to shipping platform. Descriptions of methods or devices that have proved their value are carefully considered, and those published are paid for. The rates are from five dollars upward, according to their merit

A Large Toolroom Micrometer

BY L. L. LOCKE

In the toolroom of a mid-western railroad shop I saw a micrometer that seemed unusual to me, in that it would be impossible for a man to put it in his tool box by mistake. The set is mounted on a 15x15-in. cast-iron base, having the thimble at one end and the adjustable anvil opposite to it. It is used for measuring cutters,



A large bench micrometer

reamers, large-sized drills and miscellaneous tools. In connection with a special attachment, it is used also for setting wheel-center gages up to 66 in. in length. The thimble is 5 in. in diameter and has a pilot wheel attached to it as shown. The 0.001-in. graduations are ½ in. apart. The anvil can be turned to four positions so that measurements from 0 to 4 in. can be made. A 3-in. plug, shown at the left, is used for testing the accuracy of the tool. The micrometer is considered a valuable checking instrument by the many toolmakers who use it daily.

Simplified Tool Setting

BY DONALD A. HAMPSON

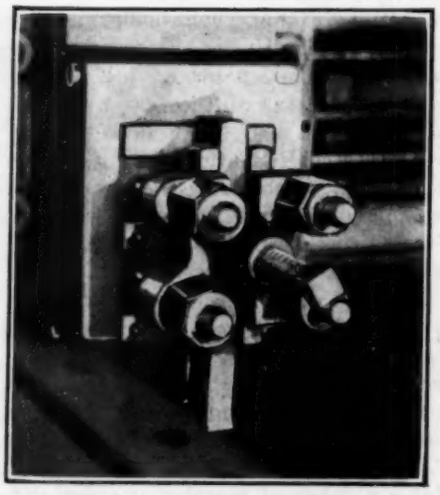
It is a well-known fact that the actual cutting time on most jobs that lie outside of the "intensive-production" field, is rarely half the total time spent on the job, the setting up, handling, trial cuts and measurements occupying as much time as that given to the removal of metal. Attempts to reduce this non-productive time are made by all foremen and planners, but it is equally well known that unless foremen keep right after the men on these things, they eventually slip back to the old ways if it is possible to do so.

Planer work always involves a goodly number of tool changes, the nature of which is such that the accuracy and finish depend upon the tools being set just so. This condition gives the workman a "handle" by which he can spend a large amount of time in grinding and setting tools while his expensive machine is standing idle.

Various plans have been presented by which the sharpening, changing and setting of planer tools can be simplified. One of the better plans is to use a single tool holder for all work, and to have forged bits to insert in the end. Such bits are sharpened by grinding on one face without changing the form. They may be sharpened and replaced without shifting the holder, and will very nearly "pick up" a cut without further adjustment. The use of such holders avoids much of the time-consuming operation of setting the tool by loosening and tightening the four nuts on the tool block.

One shop that gave the matter considerable study, came to the conclusion that these four nuts were responsible for much of the idle time of its planers. Following up that idea, it made tool guides for the blocks on a number of machines, designed to eliminate all the usual fussing in setting a tool.

The illustration shows one of these guides in place. It is a steel casting drilled to fit over the four bolts, and is permanently clamped to the block by the four nuts. There is a vertical slot milled through the center, about $\frac{1}{32}$ in. wider than the tool shanks. For fastening the tools, a single $\frac{3}{4}$-in. setscrew is used in the middle. As a vital part of the scheme, all the tools for a given planer have been selected or altered so that their shanks are of uniform size. It has been found that the scheme works out very well. Instead of having four nuts to tighten with a wrench, and a tool to hold correctly by the eye, the planer hand now has a single screw and a tool that is self-located. The old arrangement invited a lot of battering around of the tool as it was "adjusted" after



Holder for planer tools

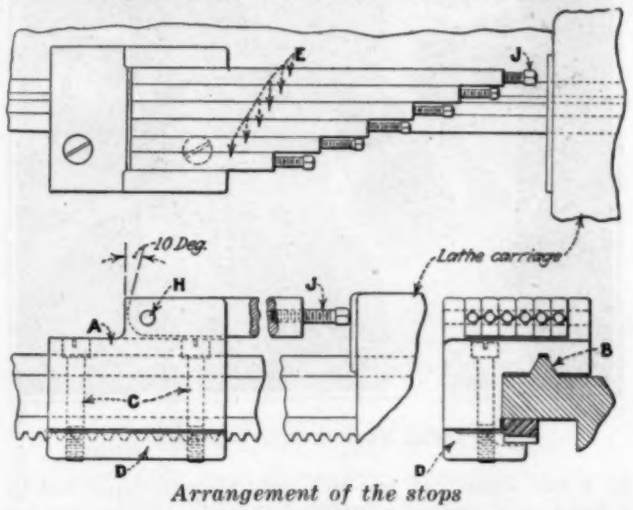
the nuts were set up. With the device described, a single screw is loosened and the tool is moved by hand whatever amount is allowed by the play in the slot—and this is sufficient, nine times out of ten. By making it impossible to get a wide range of positions, the men have found that they get along as well with the tool in one position.

And so far as holding the tool rigidly is concerned, the guides are superior to the conventional arrangement. The tool in the guide can shift only the little amount of its play in the slot, while the conventional four-nut grip is a friction grip, at best, and so requires much straining of the threads to equal the positive setting.

Longitudinal Stops for the Lathe Carriage

By Charles Parker

In some factories where small production obtains, engine lathes are used very largely for boring operations. A fixture to hold the work is suitably mounted on the carriage, and various bars are used, supported at one end by a nose piece on the spindle, and at the other end by the tailstock center, or some arrangement of



Arrangement of the stops

bushings. In such cases, counterboring or facing operations are usually done in connection with the boring, and some means must be provided to gage the different depths or lengths. Since feeds for short counterboring operations of this sort are generally completed by hand, a cut and try method in combination with a gage is generally used. This method is slow and can be greatly improved by using a series of adjustable stops as shown in the illustration. The application is, of course, dependent on the type of lathe to which the stops are to be attached.

In the case illustrated, a steel block *A* is cut and fitted to the front guide way as shown at *B*. It is clamped firmly by the two screws *C*, which are threaded into the gib *D*. The gib is cut in rack form to fit the rack on the under side of the shears. The block *A* is of course adjustable along the shears to any position.

A series of flat strips *E* are pivoted at *H*, and provided with setscrews *J* at one end. The pivoted ends are beveled to an angle of 10 deg., so that when a strip is lifted it will not drop back again and get in the way. When any stop is in use, the others (if they interfere) can be raised to a vertical position.

How Would You Do This Job?—Discussion

By Henry Seal
Nottingham, England

The article by Henry Densmore under the title given above, published on page 904, Vol. 63, of the *American Machinist*, must have caused many deep-thinking mechanics to ponder over the problem.

Several friends and myself, all of us regular readers of the *American Machinist*, have discussed the problem many times. Incidentally we have been looking each week for some comment or a possible solution of it. We agreed that if we had an order for a small quantity of the shells, we should have jig-drilled the hole from the side. If we had an order for a large quantity, we would experiment on punching the hole, using a die that was an integral part of a supporting arbor, and a stepped punch to pierce the hole in halves, successively, at one stroke.

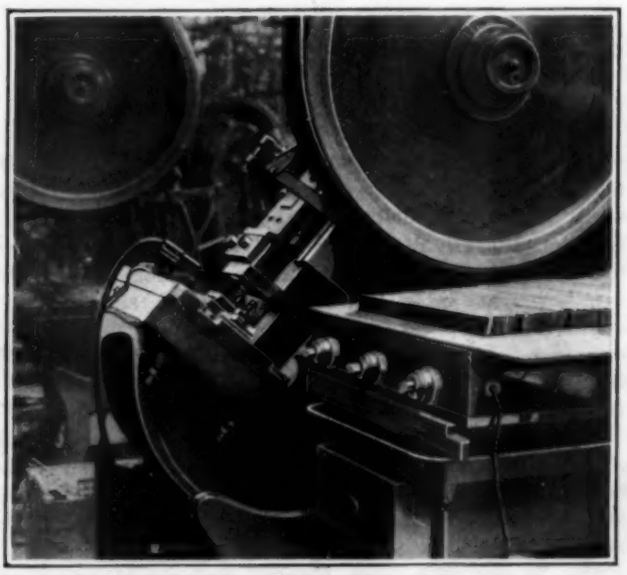
However, since Mr. Densmore has said that the tools necessary to do the job are so simple and inexpensive, that it makes one mad to think he had not invented them, we should be pleased to know Mr. Densmore's secret, either through the mail or through the columns of the *American Machinist*.

Punching Formica

By Oliver Franklin

Sheet formica often shatters if the attempt is made to blank and perforate it cold in a punch press. Heating to about 150 deg. F. removes this brittleness, however, so that intricate patterns can be punched with safety. Care should be taken to prevent overheating, since blisters will then appear and the Formica is ruined for further use.

The illustration shows one method of accomplishing this heating. A 3-element electric heater is used and it is placed beside the inclinable press for convenience of the operator. In this particular case, small insulating separators are being made for use with radio parts,



Heating apparatus for use in punching Formica

and the Formica is purchased in strip form as shown. The strips are piled on an inclined, sheet-metal tray and are fed down on the asbestos pad covering the steel surface of the heater.

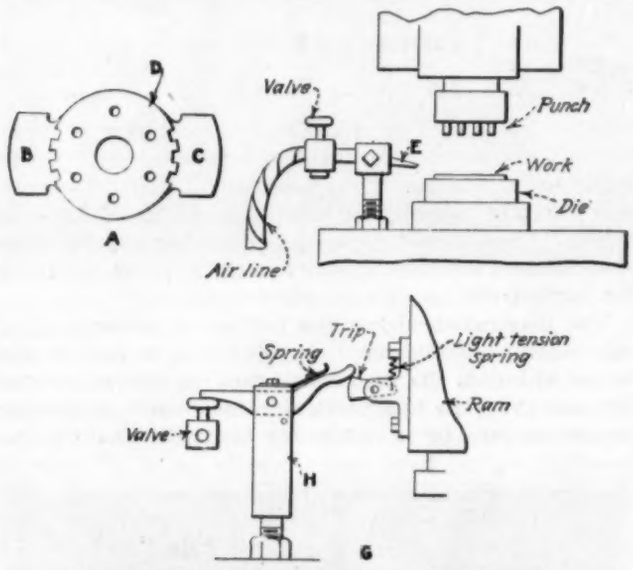
Temperature regulation is provided in several ways: The strips are warmed gradually as they approach the asbestos pad, and the operator gages the quantity of strips on the pad by his speed of handling them in the press, so that a strip does not remain on the pad long enough to become overheated. The electric heating elements can be controlled independently of each other. The strips are placed edgewise on the tray, since it was found that blistering often occurred if they were laid flat. The operator sometimes turns a strip flat for a few seconds before putting it into the press, in order to make sure that the heating is thorough. Gloves must be worn, of course, in handling the heated strips.

Air Blast for the Punch Press

BY ALEX. A. CURTIS

A great saving in time on punch-press work can be made by using an air nozzle attached to the bolster of the press, and operated either by hand or by the ram.

In the case shown at *A*, the two ears *B* and *C* were cut off at the serrated lines, and the holes and slots



Air blast for blowing scrap from the die

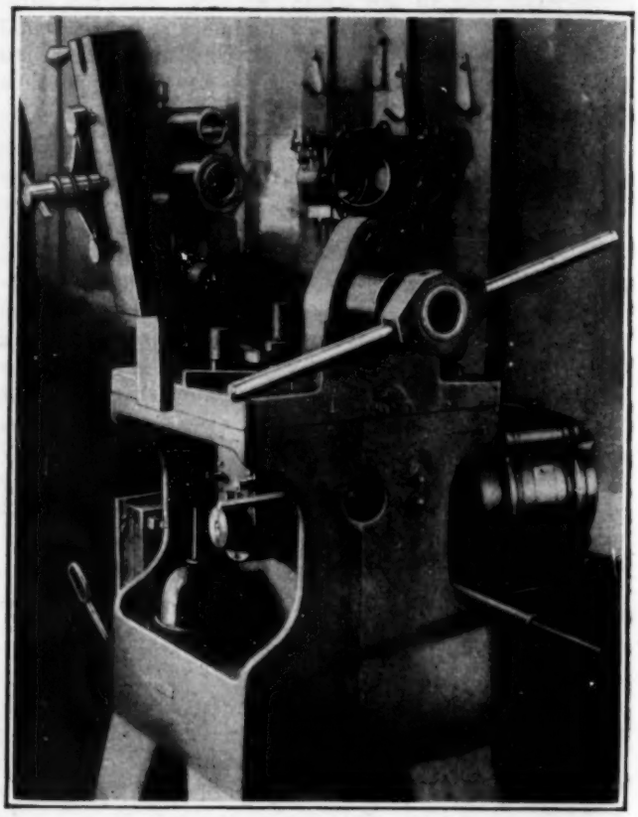
were punched at the same time, leaving the blank *D* and the pieces *B* and *C* on the die. Since the two latter pieces were discarded, the operator had to brush them off the die and remove the work *D*. It slows up the work to use a brush, so we arranged an air nozzle as shown at *E* with a plunger valve, so that the operator could press it to blow pieces *B* and *C* from the die after the piece *D* was removed. The valve was held in a holder arranged to screw into any convenient hole in the bolster.

We found this arrangement so useful that we applied it to all the presses, and in some cases where it was necessary only to remove the work and clean off the die, we added an automatic attachment as shown at *G*. The stud *H* carries a valve trip mechanism, one end of which touches the valve plunger and the other comes in contact with the trip, which is adjustably arranged on the ram.

Line Reaming Motorcycle Transmission Cases

BY GENE PHELPS

In the illustration is shown a special machine for line reaming and tapping aluminum transmission cases of motorcycles after the studs have been set. The case is located in the fixture at the top of the base and clamped



Special line-reaming machine

by a leaf plate that has two locating pins, operated by a hand knob and so positioned that they strike the top face of the case. The lower portion of the leaf plate has two bushings inserted in tubular projections that fit into the opening of case. When the leaf plate is in position, the bushings are in line with corresponding bushings at each end of the fixture.

Line reamers, passed through the bushings, size the large hole to 3⅛ in., and the smaller hole to 1⅛ in. on one side of the case and 1$\frac{7}{32}$ in. on the opposite side. A motor, mounted in the base, is used to operate a 2$\frac{1}{4}$-in. 20 tap located on the far side of the fixture. The drive for the tap is provided through gearing built into the fixture. A small amount of soda water, applied from an oil can, is used for a lubricant.

The machine is made of cast iron and is solid in construction. The holes are reamed to a 0.0005-in. limit. A finished transmission case is shown on top of the fixture. The machine was built by the Harley-Davidson Motor Co., and is used in its plant.

Mechanical counters are being used to a considerable extent to keep tally on hand-operated machines. Instead of keeping score with a piece of chalk, the operator touches the lever of the counter and goes on with his work. It's a time saver and more accurate.

Characteristics of Alloy Steels

Vanadium-Steel

Vanadium is one of the hard metals valued for its property of alloying readily with iron. It is combined with iron to make ferro-vanadium, which is used in steel making to add to the molten steel in prearranged quantities in order to give the desired characteristics to the alloy-steel.

Vanadium is one of the hardest of metals, but is brittle and crystalline in structure. It has a silvery-white lustre. Its melting point is high, 3,236 deg. F., and its specific gravity is 6.02. It does not oxidize when exposed to the air or to steam, and it is not readily attacked by acids.

Most of the vanadium now produced comes from the sulphide of vanadium known as patronite, which contains about 20 per cent. of vanadium and 60 per cent. of sulphur. The principal mines are in Peru, and are controlled by one American company. The ferro-vanadium used in making vanadium steels contains from 30 to 50 per cent. of vanadium. Its melting point is approximately 2,600 to 2,700 deg. F., and it is readily soluble in molten steel.

Only a small proportion of vanadium is required to have a decided effect on the physical properties of steel. Vanadium in small proportions increases the tensile strength and elastic limit of steel, as well as giving to it greater wearing and shock-resisting properties. The metal combines with the cementite in steel, and produces an alloy of fine grain. The grain growth is also retarded, which enables the alloy steel to withstand higher temperatures. Vanadium replaces the iron in the iron-carbide, or cementite, until all has been replaced. The vanadium carbide formed is not as soluble as iron carbide, and consequently requires heating to a higher temperature to put the steel in condition for quenching. The strong affinity of vanadium for oxygen at the melting temperature makes it a valuable deoxidizing, or purifying, agent for steel as well as an alloy.

Vanadium is employed in steel alloys either alone or with other metals, especially chromium and nickel. With tungsten it is also used to produce some of the special commercial tool steels or high-speed steels. The vanadium content of alloy steels is usually below 0.25 per cent., and seldom exceeds 1.0 per cent. The purifying action of the vanadium intensifies the characteristics derived from the other metals in the alloy. But the vanadium, in small proportions, also increases the hardness and strength of the steel on its own account without lowering the ductility. The addition of 0.5 per cent. of vanadium to a mild steel is claimed to raise its tensile strength from 60,000 lb. per sq. in. to 94,000 lb. per sq. in. In too large a proportion, however, the vanadium makes the alloy steel extremely brittle. Where vanadium is called for in S.A.E. alloy steels it is usually specified as 0.18 per cent.

Most of the commercial steels containing vanadium also contain manganese, sometimes with a higher percentage of manganese than of vanadium. Commercial high-speed tool steels with complex alloys sometimes contain as high as 2½ per cent of vanadium with a larger proportion of strength and hardness claimed at elevated temperatures directly traceable to the vanadium content.

The affinity of vanadium for nitrogen makes vanadium steels particularly adaptable to the cyaniding process for case-hardening, and they are used for such surface-hardened parts as bolts, nuts, washers, and small stampings.

The chrome-vanadium steels used in the automotive industry contain from 0.15 to 0.20 per cent of vanadium, 0.80 to 1.10 per cent of chromium, 0.50 to 0.80 per cent of maganese, and from 0.10 to 0.55 per cent of carbon. These steels are used for such forgings as axles, steering arms, connecting rods, and crankshafts. The steels of this class with less than 0.20 per cent of carbon are used for case-hardened parts such as gears.

When heat-treated, the forgings of chrome-vanadium steels are readily machinable, and have a high elastic limit up to 140,000 lb. per sq. in., combined with high ductility. Carbon-vanadium steels, with a carbon content between 0.45 and 0.55 per cent, and a manganese content from 0.70 to 0.95 per cent, are much used for locomotive forgings such as axles, crankpins, and connecting rods. Carbon-vanadium steel castings are also used for locomotive parts such as main frames and crossheads. Like the vanadium steels for automotive parts, these alloys contain about 0.18 per cent of vanadium. These castings should always be normalized and annealed before using. Vanadium-steel castings have about 30 per cent higher elastic limit and tensile strength than castings of carbon steel.

Vanadium is a constituent of many high-speed tool steels in varying amounts up to about 2½ per cent maximum. Vanadium tool steels are claimed to have a greater hardening range, and to have a greater depth of penetration of hardening. They are also said to be stronger, tougher, and to hold their edge better. As vanadium is not ordinarily the principal constituent of alloy steels it is impractical to tabulate the recommended heat-treatments for the many vanadium-alloy steels in the market. It is most advisable in each case to accept as a working basis the recommendations of the manufacturer of the particular steel.

For the information given we are indebted chiefly to material from the Vanadium Corp. of America, the Vanadium-Alloys Steel Co., and the A.S.S.T.

© American Machinist

Practical Shop Problems

Questions of a Practical Nature will be answered in these columns

Normalizing Steel

Q. I note frequently the use of the word "normalizing" in articles on heat-treating, and do not get a clear understanding of the meaning of the term. I have been in contact with heat-treating methods for a number of years, but this expression seems to be a new term in the art. Can you tell me how normalizing differs from ordinary annealing?

A. This is a relatively new term in heat-treating, although old heat-treaters have been "normalizing" for many years. Normalizing consists in heating the steel to a little above the critical point and holding at that temperature for a sufficient time to obtain a complete penetration of the heat and a consequent refinement, or "normalizing," of the grain. After removing from the furnace the steel is cooled in the air, in the case of carbon steels.

Normalizing is usually done after forging operations, and often after casting. The temperature required is always somewhat higher than that necessary for simple annealing. While normalizing was formerly taken as an annealing process, and may still sometimes be considered as such, a distinction has been made because of the difference in purpose of the two operations. Annealing is usually done in order to soften the steel for machining, while normalizing, according to the A.S.S.T. definition, has as its prime object the rearrangement of the steel grains into a normal uniform structure.

Grinding High-Speed Tools

Q. We have some difference of opinion in our tool department as to the proper methods for grinding high-speed tools, and would appreciate your advice in the matter. Should high-speed steel tools be ground wet or dry, and what is the best procedure in either case?

A. There is much general contention amongst toolmakers over the matter of wet or dry grinding of high-speed steels, and each shop must make its own decision to meet its specific requirements. Good results are being obtained by advocates of both methods when using proper care, but we feel that employing both methods in the same shop at the same time will not give best results.

The advocates of dry grinding maintain that they prefer the risk of burning without water to the liability of checking and cracking by poor distribution of the water in wet grinding. In wet grinding the tools must be flooded with a liberal supply of water, preferably by means of direct streams from both sides of the tool. If the water can be brought in to the area of contact in an even and sufficient quantity the result should be good.

If care is not taken in dry grinding "skin softening" will result. This consists of the softening of a thin layer on the surface of the tool. On account of this "skin softening" action it is necessary to use a softer abrasive wheel for dry grinding than for wet grinding.

Checks and cracks are not confined to wet-ground tools, but will also be found in dry grinding if proper care is not taken. One of the worst procedures is to dip the tool in water while grinding dry. This action will almost invariably cause checks in the tool. We believe that a mistake is made in trying to use the same grinding wheels for both high-speed and carbon-steel tools. Coarser and softer wheels are generally recommended for high-speed steel grinding, and the wheels should be dressed as soon as they start to glaze.

Copper Coating of Metal and Wood Parts

Q. We manufacture a line of toys, and I am desirous of obtaining information pertaining to the process of spraying metal to get a copper plating. Is it also possible to spray a coating of metal on wood?

A. The spraying of metals to obtain a coated article is called the "Schoop" process. The spraying apparatus consists of a gun weighing about 3½ lb., through which the metal to be sprayed is fed in the form of wire at the rate of about 12 ft. per min. At the muzzle the wire encounters a reducing flame of oxy-acetylene, and is melted. The molten metal, at the instant of formation into drops, is met by a blast of air at 50-lb. pressure, and is atomized and sprayed out in a diverging cone. The spray of metal at high velocity penetrates the pores of the object to be coated while still plastic. Any thickness of metal coating can be built up by continued application. Since the molten metal is ready to cool instantly upon striking, the method can be employed for wood coating without burning the wood.

Drilling Deep Holes

Q. We have experienced unsatisfactory results with cutting lubricants in drilling deep holes in nickel steel. Have you any recommendations in regard to the best practice on this class of work?

A. Your question is not specific enough to give exact instructions, but it appears to be a problem similar to the drilling of rifle barrels. For drilling the long holes in barrels the gun makers use special horizontal drilling machines and drills that are now fairly well standardized. We advise that you investigate to see if this type of machine can be used on your work. The oil employed is usually the best grade of lard oil, and is injected at a pressure of from 700 to 900 lb. per sq. in. A large-capacity oil supply tank is provided so that the oil will be kept constantly cold. The high pressure and cool lubricant are essential for the high-speed cutting in the deep hole.

Technical Abstracts

Good Belting

It must always be remembered by the buyer of belting that what he buys is merely an agent for the conveyance and transmission of something very much more expensive, and very much more valuable than the belt itself—namely, power. If one were handling a rare and expensive wine one would not put it into barrels that leaked, or conduct it through leaky pipes; yet that is an exact parallel to the transmission of power with bad belting. It should not be what a belt costs when bought that should be considered, but what it costs through other causes such as wasting valuable and expensive power and causing further wastage and stoppage through trouble of breakdowns. — *British Industries*, May 31, p. 249.

Co-ordinating Sales and Production

The outstanding difficulty in the problem of co-ordinating sales with production activities is the lack of understanding between the sales department and the production department. It is exceedingly difficult to compare men in the production department with men in the sales department and all that can be expected is that the management use its best judgment in making such comparisons for compensation purposes.

A good salesman is more or less of an opportunist and is more than likely rather unmethodical in his methods and rather intolerant of necessary factory routine procedure. On the other hand, the factory man realizes the necessity of routine procedure and rather chafes at the salesman's inability to understand why everything cannot be done just as and when the salesman would like to have it done. However, the factory man is very much inclined to place too much emphasis upon routine and to give not enough consideration to the customer's requirements. Unkept delivery promises to a conscientious sales department are and should be a cause of great annoyance. Two main resons have been found for failure to keep delivery promises. The first can be laid to the sales department through giving to the customer unreasonably short delivery promises. The second can be laid to the manufacturing department in not arranging their schedule and securing their material so as to be able to keep reasonable delivery promises.

The quality of product is a matter of extreme importance to any business, and the sales department is in most cases the first department to receive complaints regarding quality. The better way to handle these complaints is to first get a report through to the production department. A statement then goes back to the sales department outlining what has been found out with regard to the complaint and what steps have been taken to prevent its recurrence. In this way the production department is kept constantly informed as to how the production is functioning and the sales department is constantly informed as to what steps are being taken to improve quality. Charles R. Redding, Leeds and Northrup Co., in *The Management Review*, April, 1926, p. 99.

Rhythm in Work

The value of rhythm in work has long been recognized. In Germany the attempt has been made to let work be accompanied by a soft rhythmic tone. This tone may sound only at the beginning of a series of movements or it may follow all the movements. Direct research has shown increase in production and improved feelings among the workers even if the rhythm did not exactly correspond to the movements of the work. It is, however, possible to disturb the work seriously by a so-called counter rhythm—one which does not fit the work at all. This is stated with the reservation that certain trained workers can develop a so-called "polyphonous" connection between their work and the counter rhythm. Interesting examples of the harmful influence of noise on production are given, and there is a considerable number of pictures illustrating arrangements to secure correct posture at work, etc. The value of intermission and interchange of work every hour or every two hours is emphasized. The proximity of a congenial good worker may have an excellent effect on the speed and attitude of a poorer one. Prof. Ewald Sachsenberg in *VDI, Zeitschrift des Vereines deutscher Ingenieure*, April 24, p. 556.

The Engineer

An engineer must be observing, he must possess originality and foresight, for the profession is a highly creative one and vision and inventiveness are most desirable. He must have self control, perseverence, application, and industry, for very often progress is slow and the results disappointing. For him to lose patience or become dejected would react unfavorably on his work. He must possess intelligence and mental alertness, for he is often called upon to make quick decisions and much may depend on them. He must possess an analytical mind, for the many complex and difficult problems presented to him for solution require careful and orderly thinking. He must be open minded and free from prejudice, for he must keep up with new developments and must not hesitate to discard the old for the newer method whenever he is convinced that it pays to do so. And very important indeed, he must be practical and have common sense, for without it theory and experimentation are valueless. The engineer must have high honor; he must be trustworthy and highly dependable, for his capacity is often extremely confidential and much is left to his judgment and discretion. As to personality, he must be agreeable, his address must be pleasing and his manner convincing, for he must inspire the confidence, respect, and cooperation of his associates. He must possess a deep interest in and liking for his work, for psychological research has shown an extraordinary correlation between interest and ability. Edwin Schlesinger in *Industrial Management*, May, 1926, p. 295.

American Machinist

KENNETH H. CONDIT AND FRED H. COLVIN
Editors

Established 1877

Volume 65

WITH this issue the "American Machinist" begins its sixty-fifth volume—one step nearer to the half-century mark in its history. Forty-nine years of active service is a long time in the history of an individual or of a corporate enterprise. After such a period of activity the individual begins to slow down. The enterprise, on the other hand, is quite likely to be going better than ever with no limit in sight to its potentialities and achievements.

The new volume will be edited by this staff: K. H. Condit and F. H. Colvin, editors; L. C. Morrow, managing editor; A. L. DeLeeuw, consulting editor; and S. A. Hand, Ellsworth Sheldon, W. E. Irish, F. W. Curtis, G. S. Brady, F. J. Oliver, Jr., A. K. Burditt and H. V. Doyle, Jr.

Less Work and More of It

A MAN does more work when he doesn't have to work so hard. A trifle paradoxical, perhaps, but true when veiwed in the light of the proper facts.

"I never let a man do what a machine can do," said a railway blacksmith foreman. In about twenty years that foreman has reduced his force from twenty-two to eight men to do the same work. Many of the parts he used to forge are now cut out on the oxyacetylene cutting machine. Other machine equipment has further reduced the manual labor.

Perhaps the reduction of almost sixty-four per cent made by the blacksmith foreman is not far away from the average labor reductions in the metal-working industries during the last twenty years. Whether it is or not, the foreman has the proper viewpoint. He is following the policy that is keeping us to the front as a manufacturing nation—letting the machine do the work.

Payments for Suggestions

REWARDING employees for inventions or valuable suggestions is one of the problems for which many solutions have been tried and few found satisfactory. The primary object being to stimulate the development of ideas it is necessary to look at the employees' side of the question very carefully. For unless the rewards are sufficient to induce the employees to devise new methods, and particularly to give the firm the benefit of them, they are useless.

One of the great difficulties is that the average employee is very apt to overestimate the value of his invention. He naturally does not appreciate the cost or the difficulty involved in bringing the idea to the money making stage. On the other hand he feels that if an idea is worth enough to embody in the products of the firm it is worth more than the $5, $10 or $25 unsually offered.

As it is impossible to tell in advance much about the actual value of any invention or device, it might be more encouraging to consider the award as a first payment. Then in case the device saved a lot of money, a further reward would be both an evidence of good faith and a much greater incentive than any single prize can be. If the device proved especially valuable a periodical payment, yearly or otherwise, would stimulate every man in the shop.

This need have nothing to do with a direct percentage or royalty on its value. But if men know that the firm is willing to reward the developer of a new device somewhat in proportion to its value, it will effectually kill the idea that prizes are always inadequate.

Good Lighting Increases Safety

WE ARE totally blind without light; we are partially blind with inadequate light; and we are more or less blinded by glare from unshaded light-sources and from their reflected images. Inasmuch as we depend largely upon vision for our safety it is to be expected that improper and inadequate lighting are responsible for many accidents. Defective vision also is so prevalent that it is necessarily related to accidents. Here again improved lighting aids materially, for many eye-defects can be wholly or partially compensated by supplying a greater intensity of illumination than is required for normal eyes.

A decade ago poor lighting was found by insurance companies to be a decidedly contributing factor in one out of every four accidents. Although much remains to be done in lighting our industries, the past decade has witnessed much improvement. Higher intensities of illumination have been extensively provided and glare has been given much attention. This progress is reflected in fewer accidents attributable to the lighting conditions. At the present time improper illumination and defective vision are the major factors in one out of every eight accidents. This is encouraging but aside from considerations of production and spoilage the job of industrial lighting will not be completed until perfect safety from a lighting viewpoint is achieved. The saving through perfect safety from a lighting viewpoint will pay the industrial lighting bill of the nation.

Shop Equipment News

Sellers Drill-Grinding Machine, No. 2-A

The No. 2-A drill-grinding machine illustrated is being built by William Sellers & Co., Inc., Philadelphia, Pa. The machine is designed for 2-lip flat and twist drills from $\frac{1}{16}$ to 3 in. in diam. With a special set of jaws, it will also grind 3-lip drills from $\frac{3}{4}$ to $2\frac{5}{16}$ in. in diameter.

The No. 2-A machine supercedes the No. 2 machine. The same principles are retained, but the improved machine is much heavier than the former pattern, although the parts moved by the operator are lighter and are said to move more freely. Means are also provided for adjustment in order to maintain accuracy.

After one lip is ground the drill is released and turned so that another cutting edge is in the same position as was the first. On a 3-lip drill the operation is repeated for the third lip. In this manner the cutting edges are made alike in length with the same angle and the same cutting clearance. The clearance obtained is just sufficient to permit of free cutting without reducing the strength of the cutting edge. It is automatically determined by the machine for the various sizes of drills.

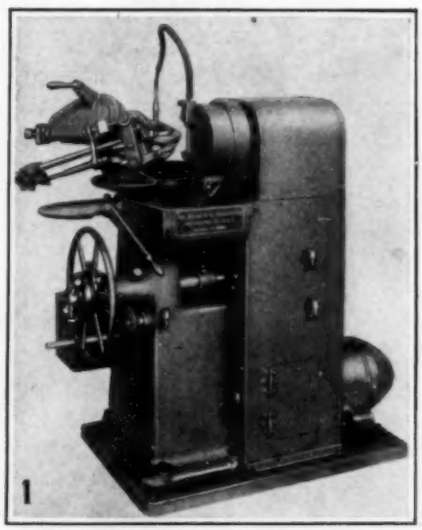
The drill is held in a check with the edge of the drill at the correct angle with the grinding wheel. The chuck holds the drill between hardened steel jaws on the flutes near the cutting edge, while a center, adjustable to the length of the drill, supports the shank end. It is claimed that by using this means of support any bend in the drill or the shank will not affect the accuracy of the cutting edge. The chuck oscillates on hardened steel centers, one of which is adjustable for wear. The chuck is balanced by a counter weight which can be set for different weights of drills. This adjustment is not always necessary, but it is of advantage where a large number of the same size drills is to be ground. The chuck can also be adjusted to grind any included angle of drill points ranging from 90 to 130 degrees.

The emery wheel is mounted on a spindle of high-carbon steel, ground to size. The spindle bearings are made of hard bronze and are adjustable for wear. The emery wheel and spindle are mounted on a swing frame, which is operated by means of a hand lever. The to and fro movement of the wheel thus obtained in a plane normal to the axis of the spindle is said to facilitate the grinding operation and to keep the working face of the emery wheel straight. The machine grinds on the flat surface of the wheel, so that line contact is made and the greatest amount of metal can be removed without clogging the wheel.

The wheel is covered by a cast-iron guard that exposes only a small portion of the wheel. The guard is of such a shape that the water is carried down to the pan without splash. A pump supplies sufficient water so as to eliminate all risk of drawing the temper of the drill.

The machine is built for heavy duty. Where necessary it can be used to re-shape a burnt-out or broken cutting edge by taking a heavy slicing cut first, followed by a light finishing cut. No parts have to be substituted in order to change from one size drill to another. It is claimed that it is not necessary to employ a skilled mechanic in order to grind drills with accuracy.

The machine is furnished with either motor or belt drive. In the former case the motor is mounted on a base plate integral with the machine. A large guard protects the motor and belt. With belt drive the cast-iron base plate is omitted and an overhead countershaft is provided.



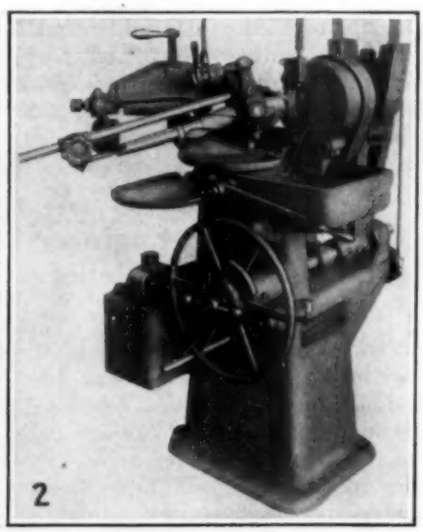


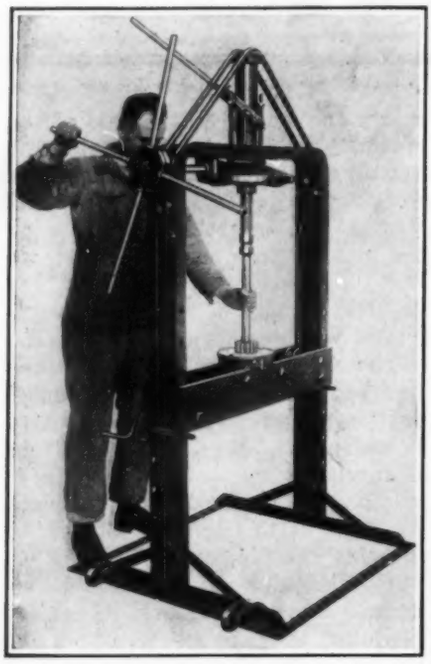
Fig. 1—Sellers Drill-Grinding Machine, No 2.-A
Fig. 2—Belt-driven model

Holmes Two-Speed Garage Press

The two-speed garage press shown in the accompanying illustration is an arbor and forcing press manufactured by the Ernest Holmes Co., Chattanooga, Tenn. It has a one-piece frame made from channel steel mounted vertically on an angle-section base, bolted and riveted together. Four bracing members are used to secure the rigidity of the structure. For convenience in moving the press, the base is fitted on one side with two small rollers which come into contact with the floor when the press is tilted.

The bolster is supported in position by means of two pins which are inserted in holes in the columns.

Shop Equipment News



Holmes Two-Speed Garage Press

A handle in the bolster raises it by means of two cables on the sides which are wound on drums by the handle. Various fixtures can be mounted on the bolster so that it can be used for forcing, straightening and bending as well as for arbor and general press work.

The head of the press has a double unit for high and low speeds which gives it capacities of 4,000 and 60,000 pounds, respectively. A lever which can be seen in the illustration provides the high-speed movement of the ram through a lever action. Springs return the ram. When used as a heavy duty press, the power is transmitted through a spider wheel operating a screw through bevel gears. The thrust is taken by a ball bearing immersed in oil.

The large bevel gear is protected by means of a pressed steel cover. The head unit is braced and held securely by means of two truss rods, bolted at the upper corners of the frame. The distance between the uprights is 32 in., and the space is 4 ft. 10 in. high.

Milburn Paint Spray

The paint spray shown in the accompanying illustration has been brought out by the Alexander Milburn Co., 1416 West Baltimore St., Baltimore, Md. It is light in weight and of a simple design so as to prevent clogging. The device consists of a cover, body, atomizer and handle and it can be used for general surfacing with paint, whitewash or oil.

The paint enters a large annular chamber surrounding the air nozzle, from which it is atomized and expanded in a venturi-shape. The atomization is regulated by turning

Milburn Paint Spray

a nozzle to secure a large or small spray or to entirely shut it off, leaving only a stream of air which can be used for dusting purposes. A pressure of 40 lb. is recommended, but it can be varied as desired.

Cleveland Tool Engineering Co. Circular Relief Grinder

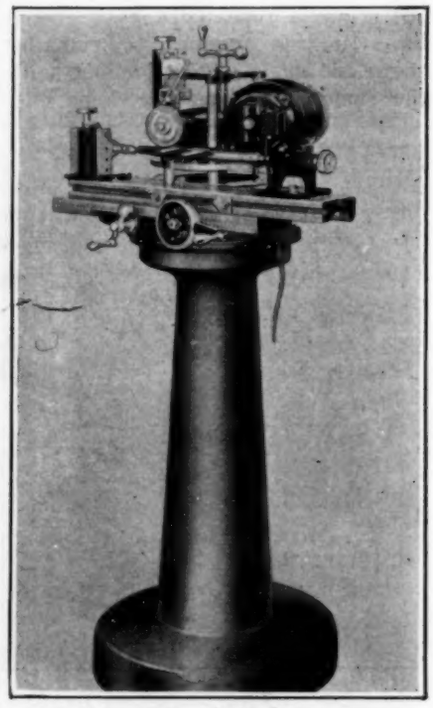
The relief grinder shown in the accompanying illustration has been designed by the Cleveland Tool Engineering Co., Main and West 25th Sts., Cleveland, Ohio, for grinding in one operation tapper taps, boiler, bridge and ship reamers, adjustable reamers, milling cutters and other tools that require clearance along the sides.

The face of the grinding wheel is dressed concavely to exactly the same curvature as that of the tool to be ground. This is accomplished by means of a diamond located above the grinding wheel. The tool to be ground is offset from the center of the curve by a transverse movement of the table. The grinding, therefore, produces a convex surface adjoining the cutting edge.

The amount of clearance is determined by the distance through which the tool is moved, in or out, against the curved face of the grinding wheel. The convex contour of the relief is claimed to leave as much metal as possible to support the cutting edge, reducing the wear.

The machine will swing work 5 in. in diam. and 15 in. long between the centers. The longitudinal movement of the table is also 15 in. The cutting wheel is 4 in. in diam. and it rotates at 6,250 r.p.m. The downward feed of the wheel is secured by means of a handle on the head, which is graduated in thousandths of an inch. For spiral work the head itself can be swung and its movement measured in degrees. The feed screw and the cross-feed are also graduated in thousandths of an inch.

A ¼-hp., a.c. or d.c. single-phase motor, rotating at 1,725 r.p.m., is



Cleveland Tool Engineering Co. Circular Relief Grinder

recommended. The spindle is of special alloy steel mounted in SKF bearings that are dust-proof. The dressing diamond is mounted in a holder that is graduated. The floor space occupied by the machine is 32x39 in. The height is 4½ feet.

Shop Equipment News

"Becker" Vertical Milling Machine No. 6

The improved No. 6 "Becker" vertical milling machine or die sinker shown in Fig. 1 has been placed on the market by the Reed-Prentice Co., Worcester, Mass. The range of the previous machine has been increased giving it a greater capacity. Fig. 2 shows the universal shaft drive to the spindle traverse with which the machine can be equipped. It is one of a line of machines built by the company of which the model D-1 was described on page 825, Vol. 50, of the *American Machinist*.

The adjustment of the head on the column of the No. 6 machine is 18 in., and the spindle has an adjustment of 10⅝ in. The spindle distance from the table to the nose can be varied between 0 and 30 in. The depth of the throat of the machine is 28½ in. The table has a working surface of 72x20 in. The longitudinal travel of the table is 72 in. while its cross travel is 30 in. The height of the table above the floor is 29 in. The rapid traverse cross and longitudinal feeds are both 125 in. per minute.

The control wheels of the machine are conveniently located and the control is designed to be as nearly from one point as possible. The belt drive to the spindle is of the usual arrangement, being carried over two idler pulleys at the back of the machine, across the top to the large spindle-driving pulley. The main casting of the machine is heavy to give the necessary rigidity to the die sinker for heavy cuts on large drop forged die blocks. The universal drive shaft to the spindle traverse can be fitted to the machine or removed quickly whenever desired.

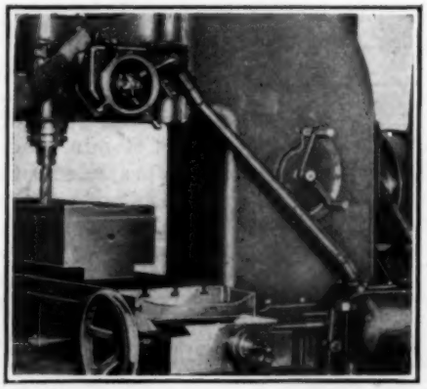


Fig. 2—View of universal shaft for spindle traverse

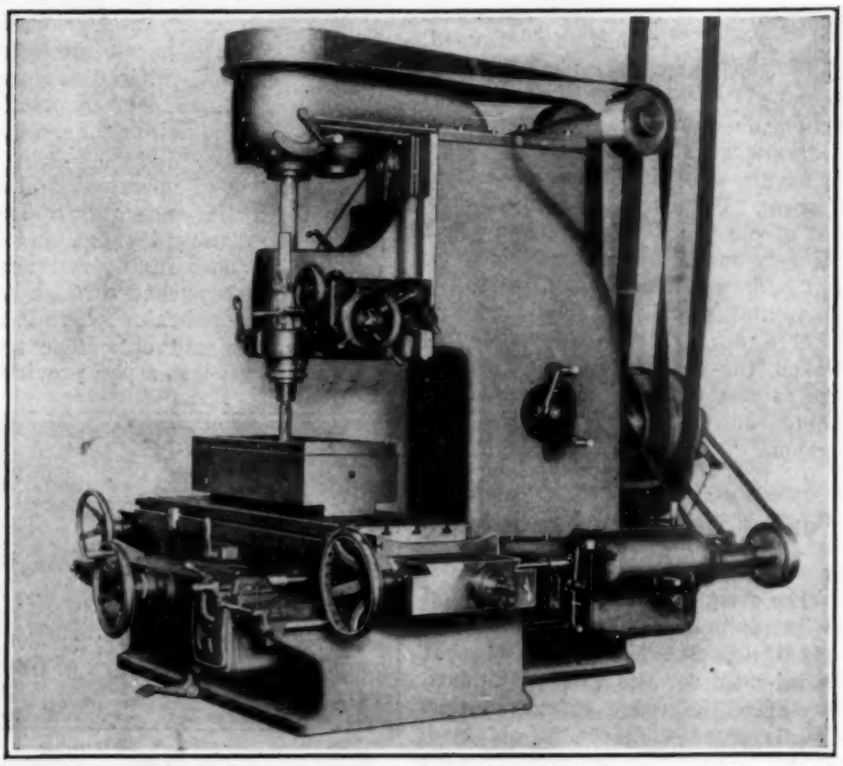
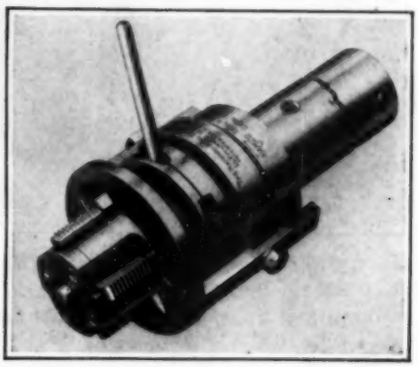


Fig. 1—"Becker" Vertical Milling Machine, No. 6

"Namco" Collapsible Taps Style S

The style S "Namco" collapsible taps are designed to replace an older line manufactured by the National Acme Co., Cleveland, Ohio. The unlimited depth model tap was described on page 1097, Vol. 45, of the *American Machinist*.

The improved model has a cup-like front plate which is heavy in construction and closely fitted over the body of the tap. Heavy screws are used to hold it in place. This design is intended to add to the rigidity of the tool and to prevent the slotted portion of the body in which the chasers are held, from springing or opening up under pressure. The method of size adjustment has been simplified, so that the tool can be adjusted for size with a few twists of a screwdriver and securely locked in position. The adjusting collar is split through its periphery and at right angles to the split are two screws. These lock screws can be loosened to permit the two adjusting screws to be set on the desired point and then tightened to hold the adjusting screws rigidly in place.



"Namco" Collapsible Taps, Style S

The chasers are supported throughout their entire length while the thread is being cut. When the core piece is rotated to the collapsing position the chasers are immediately collapsed. The tripping mechanism is actuated by a tripping ring which is set at the desired point, and when

Shop Equipment News

it comes in contact with the work it withdraws the locking pin and the chaser core is rotated.

The chasers used are of the hobbed type. Overhang chasers can be used for threading close to a shoulder if desired. The style S taps are built in fifteen sizes with a threading range for straight threads of from $\frac{7}{8}$ to $7\frac{1}{2}$ inches.

"Zeiss" Optical Dividing Head

The George Scherr Co., 142 Liberty St., New York, is introducing in this country an optical dividing head recently developed by Carl Zeiss. The "Zeiss" optical dividing head, shown in Fig. 1, is claimed to give a finer degree of accuracy than is obtained from dividing heads indexed by worms or gears.

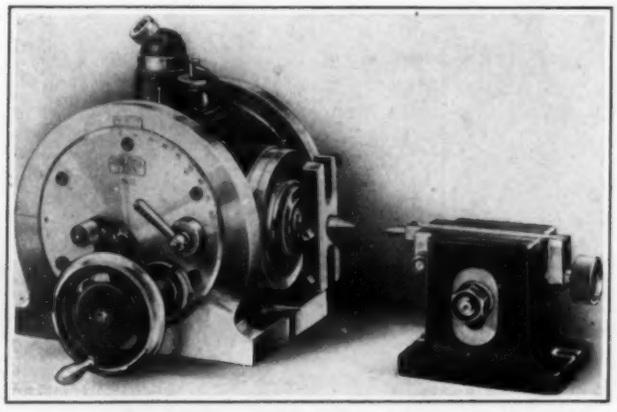


Fig. 1—"Zeiss" Optical Dividing Head

The Zeiss optical dividing head obtains the division of the circle from a glass dial illustrated in Fig. 2, mounted directly on the spindle carrying the work. In this way all errors arising from inherent errors in the gearing are claimed to be eliminated as the precision of the head depends solely on the scale of the dial. The dial is viewed through a microscope sight, which magnifies the graduation 60 times.

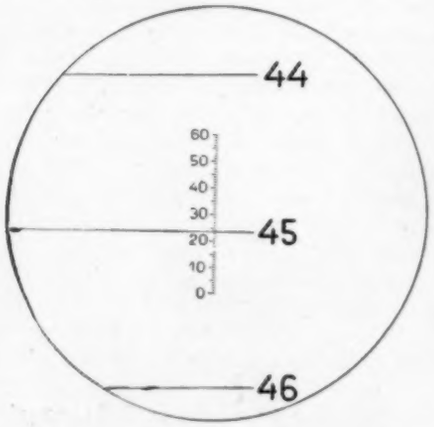
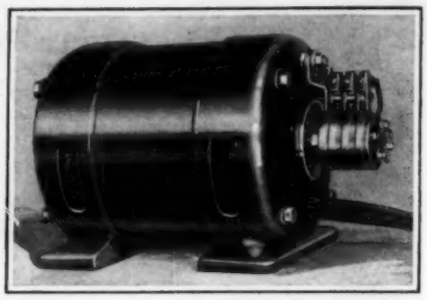


Fig. 2—The field of observation

The dial is graduated into 360 deg., and the lines of the scale appear to the eye as being $1\frac{3}{4}$ in. apart. A second vernier scale of 60-min. reading is projected into the field of observation, and it is claimed that fractions as close as 20 sec. can be estimated in the readings, which represents an accuracy of 0.0002 in. lineal measurement or a diameter of 4 inches. The dividing head is designed for rugged and continuous service. It is equipped with a dial plate on the spindle nose for coarse adjustment on ordinary work. The setting is done by means of a handwheel operating a worm. The worm is swung readily out of mesh, and the spindle locked securely during operation. The head can be swung from 5 deg. below its horizontal position through an arc of 115 deg. When the spindle is locked, the worm cannot be rotated, the ratchet device of the handwheel being automatically brought into action.

Forbes & Myers Frequency Changer

The frequency changer illustrated is being built by Forbes & Myers, 172 Union St., Worcester, Mass. It is intended for use with a standard two-speed induction motor so that four speeds in all can be obtained. When operated on 60-cycle current the frequency changer gives 240 cycles and motor speeds of 1,800, 3,600, 7,200 and 14,400 r.p.m. The capacity is $\frac{1}{2}$ kva., which is sufficient for a $\frac{1}{3}$-hp. motor.



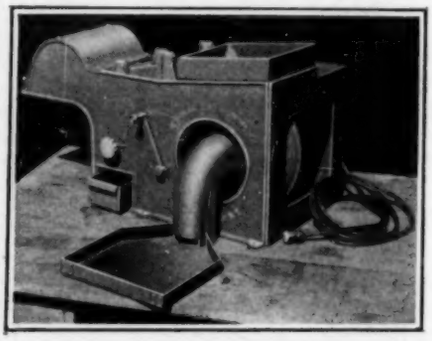
Forbes & Myers Frequency Changer

Mechanically the frequency changer is identical with a slip-ring induction motor witout the drive shaft, while electrically it has two sets of windings. One is used to rotate the machine; the other changes the frequency.

McKenzie Chip Separator

A bench machine for separating chips from small pieces made on screw machines is being built by the McKenzie Engineering Co., New Rochelle, N. Y. The large size machine was described on page 488, Vol. 60, of the *American Machinist*. This machine will separate the chips from parts up to $\frac{1}{2}$ in. in diam. and 1 in. in length made of any metal, including light aluminum, or fibre, or wood.

The principle of operation is the same as for the large separator. The material after going through an oil separator is placed in the workbox. From there it is pushed through an opening into the vibrator where it is loosened and spread out. The finished parts drop into a pan provided



McKenzie Chip Separator With Exhauster Attachment

Shop Equipment News

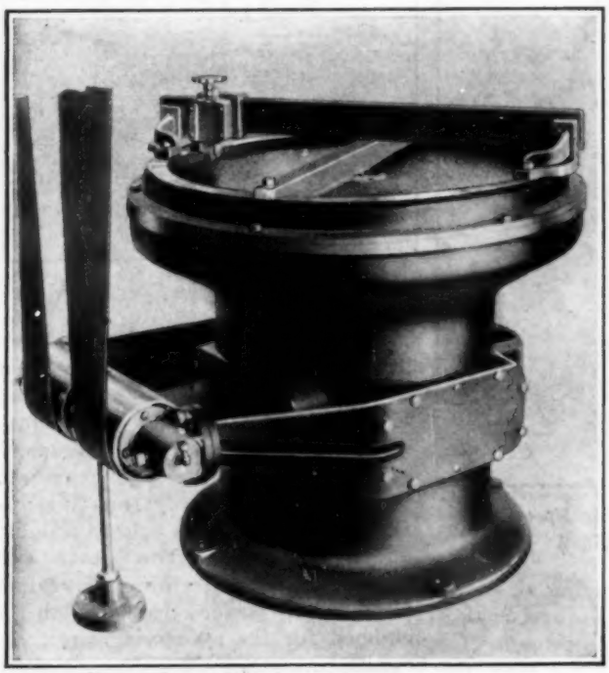
for them, while the chips are blown through a hood by means of an air stream furnished by a blower. Parts that are very small and light are separated from their chips by means of an exhauster attachment shown in the front of the machine. The material is placed in the workpan of this attachment, and is pushed to the inlet opening in the elbow. The chips will be sucked up through the exhauster and discharged through the hood, while the finished parts will drop through a hole in the bench to a box below.

A lever is provided on the separator to regulate the air blast for both blowing and exhausting, while a handwheel is used to throw a deflector for finished parts for blowing or exhausting. The blower is coupled direct to a ¼-hp. motor that is designed to run on 110-volt, 60-cycle, single-phase current. Ten feet of electric cord and plug are provided, together with the work-pans and the exhaust attachment.

The machine is 28 in. long, 14 in. wide and 16 in. high. It weighs 156 lb. net.

Gardner Horizontal Disk Grinder 30-Inch, No. 86

The line of disk grinding machinery manufactured by the Gardner Machine Co., Beloit, Wis., has been supplemented with a No. 86 30-in. horizontal disk grinding machine, illustrated. This model carries a 30-in. steel disk wheel mounted on a vertical spindle. The standard 53-in. machine was described previously on page 1064, Vol. 63, of the *American Machinist*.



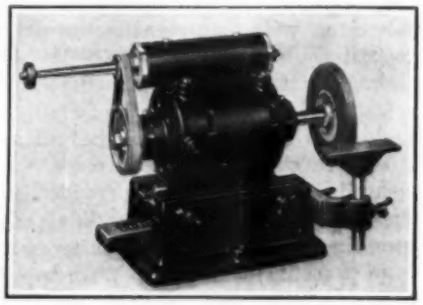
Gardner Horizontal Disk Grinder, 30-Inch, No. 86

The disk wheel is mounted on a heavy supporting flange, 16 in. in diam., which is machined and balanced and keyed to the taper end of the vertical driving spindle. The spindle is of large diameter and turned from crucible steel ground to size. It is mounted on oversize radial and thrust ball bearings having oil level lubrication. The spindle carries a pulley, and the belt from this passes over two adjustably supported, double ball bearing, oil-lubricated mule pulleys. A standard dressing device is provided for truing the grinding wheel. The truing device consists of a bar set on its edge across the top of the machine. The bar carries a holder which can slide across it from the periphery to the center of the disk wheel. The No. 86 machine can also be provided with a motor drive for alternating current. The motor used is of the vertical type mounted in the base of the machine. It is fully inclosed and self ventilated. The rotor shaft of the motor serves as the machine spindle. The floor space occupied by the machine is 46x38 in. and the weight of the grinder is approximately 1,650 pounds.

"Dumore" Base for Tool Grinding

The illustration shows the No. 2-AG "Dumore" grinder manufactured by the Wisconsin Electric Co., Racine, Wis., mounted on its base designed to facilitate tool grinding as well as internal grinding on the machine.

The base has two wing nuts to clamp the motor unit in any position desired and also carries a bracket at the right-hand end which can be similarly adjusted. The bracket has a single wing nut to permit the adjusting and clamping of the column of the small table.

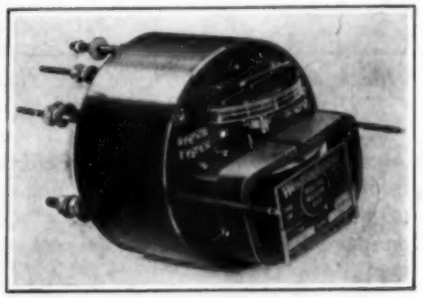


"Dumore" Base for Tool Grinding

The table is designed for use in connection with an ordinary tool grinding wheel carried by the motor unit.

Westinghouse Resistance Measuring Relay Type XM

The Westinghouse Electric & Manufacturing Co., East Pittsburgh, Pa., is marketing a resistance-measuring relay, type XM, for use with direct current. It resembles the Westinghouse induction-type a.c. relay and occupies about the same



Westinghouse Resistance-Measuring Relay, Type XM

Shop Equipment News

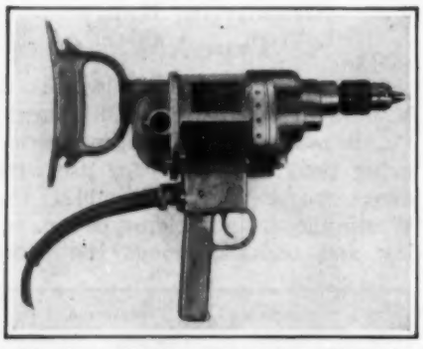
amount of switchboard space as the latter.

The relay operates on the magnetic-vane principle. It possesses adjustable features so that operating current and voltage as well as the operating time can be set. An improved form of contact that can be easily aligned or removed altogether for cleaning purposes is provided. The contacts are silver.

This resistance-measuring relay has been developed for use in conjunction with automatic service-restoring circuit-breakers. It is claimed that it actually measures the resistance of the feeder and that it recloses the breaker when indications are that the short-circuit has cleared. A time limit is provided so that the breaker is prevented from pumping rapidly when the trouble is of a recurring nature. With these characteristics this relay is particularly useful in automatic substations.

Black & Decker Portable Electric Drill, Heavy-Duty, 5/16-Inch

The Black & Decker Manufacturing Co., Towson, Md., has supplemented its line of portable electric drills with the heavy-duty $\frac{5}{16}$-in. drill illustrated, but it does not replace the $\frac{5}{16}$-in. light-duty model described on page 672, Vol. 59 of the



Black & Decker Portable Electric Drill, Heavy-Duty, $\frac{5}{16}$ Inch

American Machinist. The machine is one of a line of heavy-duty models of which the $\frac{1}{4}$-in. size was described on page 755, Vol. 63, of the *American Machinist*.

The drill is equipped with a three-jaw, hand-tightening chuck, and it will take straight shank drill bits. It is supplied with 15 ft. of duplex electric cable and separable attachment plug. The no-load speed is 1,400 r.p.m., and the weight is 10½ lb. Models can be had for use on 32-, 110-, 220- or 250-volt service.

"Sievert" Adjustable Flanging Machine, No. 4

The "Sievert" No. 4 adjustable flanging machine is built by Morey, Jones & Lovell, 810 West Sixth St., Los Angeles, Cal., for flanging work on such products as tank or condenser heads, trays and pans. It will handle circular and oval work

"Sievert" Adjustable Flanging Machine, No. 4

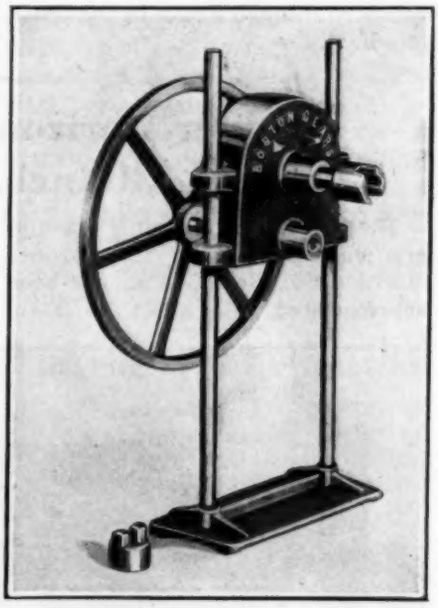
as well as straight flanging on sheets up to and including 10 gage, cold.

The No. 4 machine is intended for hand operation. As the long bar handle is drawn down a shoe holds the work on the table and a roller is moved by levers down the side edge of the table bending the edge of the sheet. The holding shoe can be adjusted by means of a setscrew to secure the desired pressure which is applied by means of a cam. The handle is counterbalanced by means of a heavy spring.

The construction of the machine is rigid and sturdy for heavy duty service. Power operated machines are also built by the company for the same purposes. Their operation is similar to that of the hand machine, illustrated.

"Boston" Adjustable Speed Reducer

The adjustable speed reducer, shown in the accompanying illustration, has been put on the market by the Boston Gear Works Sales Co.,



"Boston" Adjustable Speed Reducer

Norfolk Downs, Mass. The reducer is designed for a variety of uses in the shop, or for home applications. It consists of a compact gear transmission box fitted with "Boston" standardized gears. The gear box is adjustable vertically on two upright arms which are held in a light, but rigid, base. The gears are standard, and are interchangeable. Economical power transmission is claimed for the speed reducer.

Pamphlets Received

Empire Markets, No. 2. Canada. Prepared and published by the Dorland Agency, Ltd., Dorland House, 14 Regent St., London, S.W., England. This pamphlet is the second of a series in preparation on the markets of the British Empire, giving in as concise a manner as possible information regarding the trade opportunities in the countries dealt with. The pamphlet discusses the people and population, wealth, industry, and finance of the dominion.

News of the Week

American Society for Testing Materials Holds Annual Meeting at Atlantic City

J. H. Gibboney, Norfolk & Western Railway Co., elected president—G. W. Thompson, vice-president

All previous records of attendance were broken during the annual meeting of the American Society for Testing Materials held at the Chalfonte-Haddon Hall Hotel, Atlantic City, N. J., during the week of June 21. Up until Thursday night 891 men together with 235 ladies had registered. Methods of testing materials and the results obtained thereby were discussed by research men covering many fields—the metals, brick, tile and refractories; road materials; petroleum products; textiles; rubber; coal; timber; insulating materials; rosin; preservative coatings; and cement, lime, and gypsum. The sessions ended on Friday, June 25. Because of their diversity, many of the meetings were held simultaneously. About thirty-five of the papers presented dealt with metals. In all about nineteen projects dealing with metals are being administered by standing or research committees of the society.

The results of the election of officers were announced. J. H. Gibboney, chief chemist, the Norfolk & Western Ry. Co., was elected president; and G. W. Thompson, chief chemist, the National Lead Co., vice-president. The members of the new executive committee are Floyd M. Chapman, consulting engineer; W. F. Edwards, director of research, U. S. Testing Co.; W. B. Price, chief chemist and metallurgist, Scovill Manufacturing Co.; and H. T. Shelley, secretary and manager, Eastern Clay Products Association. In the report of the retiring executive committee it was announced that, beginning with the 1927 edition, the book of A.S.T.M. standards will be published in two parts: Part I will cover metals, Part II, non-metals. In the same report several amendments to the by-laws were offered and were approved by the meeting for submission by letter ballot to the membership. The most important of these created a student membership. The minimum age limit of 27 years for members was also dropped.

Standards of Testing

In the address by W. H. Fulweiler, retiring president, the importance of little things in the standardization of methods of testing was pointed out. In order to compare test results obtained by different laboratories it is most necessary that the tests be conducted under exactly the same conditions and with the same apparatus. Committee E-1 on methods of testing is working out such standard methods. After all, uniform tests are the language in which materials are described. In any case the limitations of each type of test should be recognized, particularly where empirical methods are used.

Scattered throughout the meetings were various reports of standing committees and usually related papers were presented at the same time. During the first session committee A-2 reported on wrought-iron pipe, staybolts, engine bolts and bars. A. N. Talbot and F. E. Rickart read a paper on the relation between the properties of cast-iron pipe tested in various ways and the corresponding properties found in test specimen, while J. T. MacKenzie discussed the proposed standard test bar for cast iron. In the same session Thomas Spooner reported for Committee A-6 on magnetic properties and submitted for approval tentative methods of test for magnetic properties of iron and steel.

Magnetic Analysis

The work of Committee A-8 on magnetic analysis was reported by F. P. Fahy. The report consisted chiefly of a paper by Mr. Spooner on "Magnetic Analysis of High-Speed Steel," which showed that there is a definite correlation between the magnetic properties of the metal and its heat-treatment. If the quenching temperature of the steel is known, the drawing temperature can be determined quite accurately, and vice versa. It was found necessary to use high induction in order to eliminate the effect of internal strains. The chief value of such tests are for a check on the quenching temperature or the drawing operations and its advantage lies in the fact that the specimen is not damaged in any way. H. Styri described how ball-bearing rings could be tested in a similar manner. The manipulation was simple. A standard ring is used for comparison and the readings of an ammeter are the only variable. The sensitivity of this form of measurement is greatly increased by displacing the current and voltage phases about 90 deg. by means of condensers. It was brought out in the discussion that followed that this method is applicable to the determination of the previous heat-treatment of small tools and that large irregular-shaped bodies cannot be so tested. The difficulty lies in getting sufficient flux through the body.

At the session on steel, revisions in several standards were approved by the meeting. These revised standards included several forms of rails, track spikes, railway and automobile springs of different alloy steels, seamless pipe, and boiler steel. Revisions in tentative standards were also approved for steel tie plates, carbon tool steel, high-speed tool steel, and carbon steel castings for high-temperature service. New tentative standards were approved for bar steel, shafting, and strip steel, and forged pipe flanges and pipe for high temperature service. All these standards include chemical properties and testing procedure.

A committee headed by G. K. Burgess, of the Bureau of Standards, reported on an investigation of the effect of phosphorus and sulphur in rivet steel. It was found that the strength of riveted joints decreased after 0.08 per cent sulphur has been reached. No definite effect on tensile strength, proportional limit and yield point could be found for sulphur ranging up to 0.18 per cent, although percentages of elongation and reduction of area decreased after 0.06 per cent sulphur.

An animated discussion of the causes of embrittlement in boiler plate followed the reading of a paper on the subject by S. W. Parr and F. G. Straub. The authors contended that embrittlement occurs in the presence of sodium hydroxide when the yield point has been exceeded. Several miscellaneous papers were also presented on the creep effect in steel, the strength of structural shapes at high temperature, and defects in large carbon vanadium forgings.

Welding Steels

J. R. Dawson discussed welded joints in steel. His tests showed that out of 72 tests on welded ½-in. steel plate, only 8 specimens broke in the weld. He estimated that the welds were 40 per cent stronger than the base metal. Other tests on 51 samples, gave 46 failures at an average distance of 1.4 in. from the weld and an average strength of 52,000 lb. per sq.in. under static load. These welds were made by a group of average workmen. With high strength plate and the same rod an ultimate strength of 67,000 lb. per sq.in. was obtained. The rod contained 0.20 per cent carbon, 0.80 per cent manganese, and 0.60 per cent silicon. These constituents produced a slag that prevented oxidation of the weld.

At the session on corrosion and fatigue of metals, the meeting approved tentative specifications for the following: zinc-coated wire, galvanized iron or steel telephone wire, and galvanized iron or steel tie wires. The results of corrosion tests on iron and steel at Fort Sheridan, Annapolis, and Washington were reported. Corrosion tests on non-ferrous metal are also being carried on by fifteen laboratories. It is estimated that over $24,000 has been expended to date on this work. Interesting developments in the so-called rustless iron were told by T. H. Nelson. It is now possible to draw high-chrom-

ium steels into tubing from 1 to 6 in. in diameter and from No. 20 to No. 9 gage. The metal has been fabricated into tanks by means of rivets, in which case it was found advantageous to countersink slightly the rivet holes in order to prevent the production of V-notches in the rivet heads. The metal can be cast, but it is hard to machine. It can be welded also, provided grain growth can be stopped. It is extremely brittle when hot. In general, the higher the chromium content, the more resistant is the metal to corrosion and the more brittle; for better physical properties the chromium content should not exceed 16 per cent. The addition of 1½ per cent silicon prevents contact corrosion with non-ferrous metals.

Discussions on Fatigue

Several papers on fatigue were presented. D. J. McAdam, Jr., showed that corrosion has a very important effect on the fatigue life of Monel metal. In some cases a reduction in load of 40 per cent was noted for the same life. In each case the fatigue crack started in oxide or rust patches. This effect would explain some otherwise mysterious failures of steel much below the normal endurance limit. A paper by R. R. Moore brought out the interesting fact that a continuous thread on a bar will result in a reduction to 75 to 80 per cent of the bar strength, while a single radial groove may result in a reduction to 23 per cent of the original bar strength in the case of a sharp V-notch. For notches of appreciable radius the effect is not so pronounced. Another paper related to fatigue phenomena was presented by P. L. Irvin. It showed that the same fatigue effect was produced by direct stress of tension and compression as for alternate flexure.

Committee B-2 on non-ferrous metals proposed revisions in tentative standard specifications for aluminum ingots, sheet, and alloy castings and proposed new tentative standard specifications for aluminum bronze castings; for the alloy: copper 88 per cent, tin 8 per cent, zinc 4 per cent; for steam or valve bronze; for composition brass and for aluminum-base, sand-casting alloy ingots. These proposals were all approved by the meeting. Approval was also given to the proposal to advance to standards, the tentative standard specifications for white metal bearing alloy and for aluminum for use with iron and steel.

Some interesting studies on the heat-treatment of duraluminum sheet were noted in a paper by R. J. Anderson. In the first place this metal is subject to a hardening-on-aging effect. The best annealing temperature is 350 deg. C. followed by air cooling, as with any temperature above this hardening-on-aging occurs. The tensile strength when fully aged is 25,000 lb. per sq.in. for full anneal. The effect of furnace cooling is to raise this to 33,000 lb. per sq.in. Heating to 512 deg. C. followed by water quenching results in raising the tensile strength to about 65,000 lb. per sq.in. The strength and hardness rise rapidly at first and then more gradually until about 72 hr. have elapsed when equilibrium is reached. Further aging has little effect. Brinell hardness ranges between 130 to 145 in this state. Aging may be accelerated by raising the aging temperature but the maximum results are less than those obtained at lower temperatures. The time for soaking at the quenching temperature is relatively unimportant. Thirty minutes is ample time for sheet stock. On the other hand too long periods of soaking results in gassing of the stock. Oil and water both give good results for quenching. In general the more drastic the quenching the greater the strength and hardness.

The report of Committee E-4 on metallography contained some valuable information on X-ray analysis. In this report, tentative recommended practice for radiographic testing of metals was proposed as well as tentative practice for care of the eyes when using a microscope. Both these practices were approved by the meeting. A complete glossary of terms relating to radiography as prepared by L. W. McKeehan, of the Bell Telephone Laboratories, was appended to the report and is a valuable contribution to this new branch of science.

Dr. Arthur N. Talbot, past-president of the society, delivered the Edgar Marburg memorial lecture. His subject was "Research and Reinforced Concrete as an Engineering Material." This was the first of what is intended to be a series of annual lectures in honor of the first secretary of the society.

Guggenheim Air Fund Will Back Competition

Harry F. Guggenheim, president of the Daniel Guggenheim Fund for Promotion of Aeronautics, has announced that the board of trustees has decided to organize an "Open International Aircraft Competition," appropriating out of the $2,500,000 given to start the fund probably between $150,000 and $200,000 to make the competition interesting and attractive to the best designers and manufacturers of aircraft throughout the world.

The competition will be held in this country. Experts from many countries will be consulted in framing the rules and regulations governing the contest and special emphasis will be placed upon safety. It is believed that such interest will be aroused that this contest will not only become an actual inducement to rapid development of safety, but also serve as a demonstration of the great progress which has been made in the direction of safe flying.

In addition to the international competition the trustees have authorized the officers to make a careful investigation and prepare further specific recommendations for encouragement of: (1) Perfection of flying instruments and accessories with particular regard to perfection of radio or other aids to navigation and the control for fog flying; (2) research in aerology; (3) development of means to prevent collision; (4) development of aircraft with motor accessible in flight; (5) development of fire and splinter-proof fusilage.

Dr. Klein Pleads for Less Waste in International Advertising Methods

In an address before the Associated Advertising Clubs of the World, in convention at Philadelphia, last week, Dr. Julius Klein, director of the Bureau of Foreign and Domestic Commerce of the Department of Commerce, urged his audience to lend their efforts to make advertising a real force for sound, constructive development as a contribution to international business.

In a program for the betterment of international advertising. Dr. Klein asserted, advertisers have an opportunity to help develop sound and lasting foreign trades for their clients by furthering "long-view sales programs" and by discouraging "fly-by-night boosters" who sell only for the sake of temporary returns.

Dr. Klein's view on world business prospects was wholly optimistic as he surveyed trade progress and pointed out to the advertising men the chances for them in the international field.

Good Will Progressing

"The fever of nationalism with its embittered reactions against international commerce, transportation and finance is gradually subsiding," he said. "The recent spectacular understanding at Locarno came not so much as the inauguration of a new period of international collaboration, but rather as the culmination of a progressive development of economic accord which has been gathering strength for some time."

For the first time since the war, the trade of the world has reached its prewar volume, Dr. Klein said, quoting figures based on a Department of Commerce world trade survey.

The international advertiser's chance, it was stated, includes an opportunity to exploit the improved buying power and higher standards of living in new markets across the Pacific and in South America.

"A new world of business opportunity has come into being," said Dr. Klein, "and its intelligent cultivation rather than ruthless haphazard exploitation is one of the prime responsibilities of the international edvertiser as the adviser of modern business."

The speaker laid great stress on the evident waste in present international advertising. On this subject he said:

"The campaign for the elimination of waste in industry and trade which is being waged by the Department of Commerce under Secretary Hoover's leadership has been concentrated against fifteen major types of avoidable losses. The thirteenth of these is described as "waste due to the enormous expenditure of effort and money in advertising and sales promotion without adequate information on which to base such campaigns." The solution of this problem would seem to be an admirable objective of the present meeting, for it is precisely in that field of inadequate information or even deliberately distorted misinformation that we find one of the gravest outstanding difficulties in international economic relations.

"There never has been any question

about the economic value and importance of advertising among those who are informed as to its real purpose and possibility. It is, therefore, a matter of profound importance, to say nothing of professional pride for the advertising fraternity, that its growing powers should be concentrated upon the elimination of these wastes due to ill-advised sales effort. The amount involved in these losses may never be known even approximately.

"It would be difficult in the present case to arrive at any concrete tabulation as to the waste incurred through injudicious advertising and sales effort in foreign trade, but all of us, I am sure, who are in touch with overseas selling have been repeatedly depressed with the haphazard exploitation of this rich field especially by the casual pretenders in business whose only interest is some momentary profit and whose spasmodic ventures have done more to demoralize and disturb legitimate effort than any other one element in international business."

Touching on general business conditions, Dr. Klein said: "It is true that there are occasional doubts expressed as to the world business outlook; the pessimists we always have with us. I wonder, however, whether in many cases they are mistaking for clouds of conflict what really is the dust arising from the work of economic reconstruction, of clearing away the debris accumulations of recent years and the laying of foundations for the permanent edifice of world business. I suppose we must always expect to hear the doleful assurances of professional viewers-with-alarm to whom every rumbling must be an ominous foreboring of impending trouble when in reality it is increasingly apt in these days to be the roar of industry as it gains momentum in all parts of the world.

"There are, of course, a number of trouble spots still vexing business in different quarters of the globe but speaking in large terms their chief significance is unimportant.

"But in spite of all these—and they admittedly do have their significance for the world of diplomacy and politics and perhaps even of certain raw material concessionaires—there can be no doubt whatever that international business is not only making progress, but it has made progress."

The Pei-Yang University

The Pei-Yang University, Tientsin, China, is making an appeal for funds or machine equipment for its engineering work. It will also appreciate proposals for machine equipment at special prices.

It was established in 1895 and teaches mechanical as well as other branches of engineering. The Chinese Embassy in Washington will receive donations or proposals.

Fifty-eight employees of the Fort Wayne, Ind., works of the General Electric Co., received a total of $1,095 in awards for suggestions during April, this being the highest amount ever paid by that plant. There were sixty-three suggestions approved by the committee, five employees receiving awards for two suggestions.

Dodd Sees Distribution as Biggest Problem of Industry

Lack of knowledge of the volume and flow of commodities was held accountable for the major difficulties confronting American industry by Alvin E. Dodd, manager of the domestic distribution department of the Chamber of Commerce of the United States, in an address on June 2 before the National Pipe and Supplies Association, meeting at White Sulphur Springs, W. Va.

"Business has so increased its productive capacity," said Mr. Dodd, "that it is becoming more and more apparent that the greatest problem with which it now has to contend is to find the most effective way of disposing of the goods it produces. Unfortunately our knowledge of distribution does not measure up to our knowledge of manufacturing. While many facts concerning it are known, the outstanding and accusing fact is the great mass and importance of the unknown."

He declared that our population has grown but it has not been able to assimilate the entire output of our factories and as a consequence there has been immense effort to discover new methods of sale. To stretch the national income to cover the gap between consuming and producing capacity instalment selling has been devised. This is the manifestation of the new competition,—the competition between industries and not the competition within an industry, the struggle to acquire a share of the limited income.

One practical step toward the solution of the problem of distribution is the proposed census of distribution. This is now being discussed with Census Bureau officials. It is possible that this will be taken at the same time as the Census of Manufacturers, as of the year 1927.

Decline in Exports for First Quarter

Restricted European buying was largely responsible for a 12 per cent decline in American exports for the first quarter of this year, says a statement based on a quarterly analysis of the distribution of this country's foreign trade issued by the foreign commerce department of the Chamber of Commerce of the United States.

It was pointed out in the statement that Europe's purchases were 28 per cent less than a year ago while United States exports to every other section of the world increased from 6.1 to 25.9 per cent. Depression in Europe reduced her takings of American cotton and foodstuffs and our smaller grain crops tended also to limit our exports.

Europe bought only 48 per cent of our exports in the first quarter of 1926, as compared with nearly 59 per cent a year ago. Exports to countries in North America rose from 20 per cent of the quarterly total in 1925 to 24 per cent in 1926. Asia bought 12 per cent of the total in 1926, as compared with 10 per cent in 1925; South America from 7 per cent in 1925 to 10 per cent in 1926. Each of the remaining grand divisions showed gains.

Twenty-three foreign markets purchased $10,000,000 worth or more of our exports, twelve of these purchasing more in 1926 than in the corresponding period in 1925. The increase among this select class follows: Canada $28,672,000; Australia, $6,984,000; Argentina $2,657,000; China, $8,173,000; Brazil, $1,478,000; Philippine Islands, $1,042,000; Denmark, $198,000; British India, $3,902,000; Colombia, $4,027,000; British South Africa, $1,431,000; Chile, $3,634,000; and New Zealand, $3,215,000.

Western Reserve Confers Degree on F. A. Scott

At the commencement exercises at Western Reserve University on June 16, the degree of Doctor of Laws was conferred on Frank A. Scott, president of the Warner & Swasey Co., of Cleveland. Mr. Scott was presented by Newton D. Baker, former secretary of War. Mr. Baker said:

"I have the honor to present to you for the degree of Doctor of Laws, Frank Augustus Scott, a citizen of Cleveland, whose services to his city have been continuous and conspicuous. Throughout the years of his life among us he has developed a mastery of those intricate processes upon which modern business depends and supplemented them with that foundation of character without which no enduring success is possible. In every great and good cause which has looked to the development of Cleveland and the furtherance of its higher interests, Mr. Scott has had an eager and helpful part."

In presenting the degree to Mr. Scott Dr. Vinson, of the university, said:

"Frank Augustus Scott, for life-long pursuit of culture, for the application of the powers of a constructive mind to problems municipal, state, and national, and for the benefits secured through your unselfish public service, upon recommendation of the faculty and by the authority of the board of trustees, I confer upon you the degree of Doctor of Laws and present you to oncoming generations of students as an example worthy of emulation."

Senate Vetoes Inquiry

On the ground that such an inquiry would be unnecessary and too expensive, the Senate committee on education and labor has submitted an adverse report on the resolution introduced by Senator Sheppard, Texas, for the creation of a special Senate committee to investigate steel, aluminum and textile mills and report on working conditions and wages with relation to the cost of labor to the price of the finished products.

The committee communicated with the National Bureau of Economic Research, which estimated roughly that such an inquiry would cost "tens of thousands of dollars." The committee reported that no useful purpose could be served by such an investigation.

The Business Barometer

This week's outlook in Commerce, Finance, Agriculture and Industry based on current developments

By Theodore H. Price
Editor, *Commerce and Finance, New York*

(Copyrighted, Theodore H. Price Publishing Corporation, 16 Exchange Place, New York)

"WHERE does all the money come from?" is the question that a prominent New York banker asked me as we walked up town together last week. "Formerly," said he, "this would have been the dull and digestive season, but the demand for good investment securities seems insatiable and we are doing more business than in January. The savings banks, the life insurance companies and all the other reservoirs of capital seem to be full of money and the fund seeking employment is being augmented by remittances sent here from Europe."

"We all know," he added, "that a turn must come sometime. My experience suggests that it is overdue, but I confess that as I study the horizon I can see nothing that indicates any serious change or reaction."

This colloquy is quoted because it probably reflects the mental attitude of most intelligent students of financial affairs in the United States. They are amazed by the country's wealth and their amazement makes them cautious. The course of the stock market indicates this. Every time it strikes a new high it sells off, as those who are long take their profits. Then it goes up again on buying by those who seek to invest their accumulating bank balances. Speculation in the Wall Street sense is lacking. The price level is so high that pyramiding is discountenanced and the reckless spirit that made last winter's boom dangerous is entirely lacking. In fact it might be said that hand-to-mouth buying has become the rule in the investment market as in other lines of business, and that the securities now being bought are being paid for to a larger extent than ever before in the history of the stock exchange.

Of course this makes for stability and it is doubtful whether American business has ever previously been as free from distension as at present.

Bank holdings of commercial paper indicate that commercial inventories are low, but the car loadings and bank clearings bespeak a large and rapid distribution of goods and business appears to rest upon an unusually firm foundation.

The various commodity markets have been normally responsive to seasonal influences but no broadly significant changes have occurred.

Corn and wheat have been steady. Sugar has declined under heavy tenders for July delivery which seem to have cleared the atmosphere. Coffee shows some advance on the successful flotation of a Brazilian loan in New York. The decline in rubber appears to have been arrested and new crop cotton is lower on improved crop accounts although the strength of July delivery has restrained short selling.

What's Doing in Industry

Business in machinery and machine tools appears spotty throughout the country. Some localities report increased activity while others report slowness. The consensus of opinion seems to be that while present sales volume is at a fair level, new inquiries have fallen off so that the outlook for summer business is uncertain.

The South presents an encouraging picture, with textile and general industrial construction promising some very good business in the next few months. In New York the market is active on old quotations but inquiries have fallen off. The New England States report a busy season with most plants running full schedules and machinery sales keeping pace. The Canadian market is active, a fair demand for equipment being present in steel and construction lines.

Detroit reports no widespread demand for tools, although some of the larger automobile plants are buying tools for replacement. Cincinnati sales are holding up and inquiries are fair. Some increase in sales is noted in Indianapolis and the outlook is good. Chicago is working on some promising railroad business.

Taken all in all, the week has been uneventful and nothing has occurred to disturb the tranquility of a business situation that is satisfactory without being sensational.

In the dry goods market small but frequent orders have been the rule and jobbers continue to complain although the offtake must be larger in the aggregate. The cotton and woolen manufacturers continue to threaten curtailment but the amount of raw material going into consumption seems inconsistent with the pessimistic predictions that are current and the demand for silk and rayon has improved with warmer weather.

Some authorities insist that there has been a slight increase in the amount of steel ordered and prices appear to be well maintained. But the trade estimates of production put it at from 75 to 80 per cent of capacity as against 84 per cent in May. This decline is seasonal but it may also reflect the admitted decrease in building activity.

Taken all in all the week has been uneventful and nothing has occurred to disturb the tranquility of a business situation that is satisfactory without being sensational. The weekly statement of the Federal Reserve Banks shows a reserve ratio of 76 per cent and as long as the supply of lendable credit exceeds the demand the markets will probably be more sensitive to bullish than to bearish news.

The passage of the Haugen Bill might have caused a rise in agricultural staples but the Senate has finally turned it down.

It is however evident that there is more sympathy with the farmers among those who shape public opinion in the larger cities. It is difficult to say whether the change is due to the Iowa primaries or a quickened and more intelligent self-interest. But whatever the cause it is plain that agricultural relief will be a major issue in the Congressional elections that are to be held in November and that it will be widely discussed during the campaign that will begin with Labor Day. As that festival is only two months off, it is possible that business may be slightly affected by the fear of radicalism that some conservatives profess.

But John Stuart Mill said "Although the American people when confronted with a grave economic question have often seemed upon the point of doing the wrong thing, their common sense has always prevailed and they have done the right thing."

This statement is as true today as when it was first made some sixty years ago and it is now quoted to reassure those who forget that the radicalism of today is generally the conservatism of tomorrow.

It is undeniable that in our economic system the farmer is at a disadvantage and any measure that will secure for him a larger share of the wealth that he creates will benefit everyone.

The Industrial Review

Progress of the machinery and machine-tool business in various parts of the country

THE following reports, gathered from the various machinery and machine tool centers of the country, indicate the trend of business in these industries and what may be expected from the future:

Southern District

A fair increase in sales is reported for this district in the past two weeks. Business is slightly in excess of last year, but not yet up to expectations. Compared with the slump during the earlier part of the spring, however, sales are good, and with a fair June business the first half of the year will compare favorably with the same period last year when an unusually good business was enjoyed.

The call from smaller shops is not active, here, but service stations and garages are beginning to buy again, and there is promise of continued good business in this field during the summer. A large part of the purchases, however, are for new and rebuilt equipment, though some sales of new tools are reported including lathes, cylinder grinding machines and drill presses.

The textile industry is also active. A $3,000,000 project is now in progress in Georgia that will be the largest plant in the world making cord tire fabric, and this will create an excellent market for Southern distributors. Considerable textile mill construction is in progress throughout the South.

Road building and contractors' equipment continues to improve with good sales reported all over the Southeast. Woodworking machinery is becoming more active again after three or four comparatively dull weeks.

Railroads are inquiring and steadily increasing their purchases, with the outlook very good for summer due to several large shop and terminal projects under way.

New York

An increase in railroad activity in the past week has brought a fair amount of business to this market. Opinion is that old quotations are closing, but the number of new inquiries has fallen off to some extent. The New York Central, the Chicago, Rock Island & Pacific, the Illinois Central and the Texas Pacific are mentioned as buyers of tools in the past ten days.

The local market has received several orders from concerns in the Mid-West, but buyers in the local territory have been rather dilatory. General manufacturers and machinery jobbing shops have bought some equipment but orders are small and leave much to be desired in total volume.

A partial list of machines ordered includes: 4 automatic milling machines, 3 vertical shapers, 2 automatic grinders, 3 single-spindle drill presses, 2 geared-head lathes, 2 Lincoln-type milling machines, 3 car-wheel borers, 2 axle lathes and a variety of single machines for miscellaneous shop work.

The second-hand market is a little better off than previously, recent auctions helping to provide good offerings for dealers.

Canada

As a consequence of the marked improvement in all lines of trade and industry in Canada, the demand for machinery and machine tools continues at a level considerably higher than at this time last year. Prospects are that business in this line will hold up well throughout the summer months and well into the fall.

The steel trade, especially in Central Canada, is well employed. The volume of new buying is encouraging and manufacturers regard the last half of the current year as quite promising. The general run of buyers, however, are holding down purchases to absolute necessities, but while orders are for small amounts, they are marked for quick shipment. The Noranda Mines Co. has just placed a large order for structural steel. After being idle for nearly four years the West End plant of the Hamilton Bridge Works Co. will be reopened soon.

The granting of a rebate on motor accessories and the remission of the 5 per cent excise tax on motor cars has had the effect of clearing away the cloud of uncertainty surrounding the automotive industry which resulted from recent tariff reductions. Optimistic statements of plans and policies indicate that this industry is entering upon a period of expanding business. One of the outstanding announcements is that construction of a $500,000 addition to the Oshawa plants of General Motors of Canada will be commenced immediately.

Cincinnati

The majority of machine tool manufacturers in Cincinnati report that they just about held their own in the past week, but a slight increase in sales is reported by a few. Selling agents state that while it was a dull week with them it was better than the same week last summer.

Taking the trade as a whole, it seems that there was a larger volume of orders booked in June than there was in the same month of last year. The majority of manufacturers report that sales were larger in June than in May.

There was no outstanding feature in the past week's market, the purchases having been made by machine tool users in various lines, none buying any considerable amount. Most of the orders continued to be for single tools, for replacement purposes, these coming from all sections of the country. The buying was well diversified in respect to sizes and types of tools.

Railroads did very little buying in the week, but it is stated that several large orders are pending. Some purchases were made by concerns in the automotive industries, but not enough to make this a market feature. Inquiries arrived during the week, coming from all sections of the country and from machines tool users in all lines. A few inquiries indicated that business extension is contemplated.

New England

The holiday shutdowns by factories are an index to business conditions and the duration of these in the New England territory indicates that business here is normally good. In New Britain, for instance, machinery builders will close only for the holiday observance on July 5, while in some other lines of trade the shut down will be of ten days duration. In Bridgeport and Waterbury machinery builders will close only one day and one or two shops in Hartford will close from Friday night to Tuesday morning, allowing employees an extra day for vacationing. No long vacation shut downs are imminent.

The first six months period of 1926 has ended, and in retrospect it was a season of good trade activity with business improved as expressed by manufacturing heads in figures ranging from 25 to 50 per cent better than in the corresponding period a year ago. And it is the concensus of machine builders that this healthful condition will maintain for the rest of the year. Contracting machinists report that billings for the period were less than a year ago, but revenues were in some cases, 35 per cent better.

Detroit

While some small orders for machine tools and machinery are seeping through the automotive factories to local machine tool dealers, there is no widespread demand for either new equipment or replacements in Detroit plants.

Large sales in southeastern Michigan during the early months of the year led many to hope that 1926 would be a banner year. One of the largest dealers in the city declares that enough business is coming in to keep the books in the black, and this fact is encouraging. Others feel that the first of August or the first of September will find a decided improvement in the market.

Things are quiet at the Ford plants, but developments are likely to come thick and fast before many weeks have passed. The new light job of the Chrysler Corporation has required very little new equipment, the old machinery being used practically in its entirety. Packard has ceased buying, temporarily, and the same is true in the toolrooms of other automobile plants.

Dodge and Hupmobile are preparing lists for new cars which it is expected will be brought out within the next few months. The possibility that Cadillac will bring out a new light eight has now reached the stage of development where it has become a probability. Paige and Jewett are buying little except to bolster up the assembly lines in a few places, while Studebaker remains an enigma to local dealers.

Chicago

Little change in the machine tool market has been noted during the last week. The volume of business transacted is about on a part with that of the two weeks preceding. Inquiries are not quite as plentiful as they have been, and but little actual buying is reported.

Some disappointment has been expressed at the failure of railroads to close outstanding lists, but special inquiries from this source lead to the belief that some good sales will shortly materialize. The Illinois Central, the Santa Fe and the Rock Island roads have placed some orders for single tools, but with these exceptions there has been little railroad buying.

Business in grinding machines continues satisfactory, and manufacturers representatives of this line have every confidence that it will undergo no change for months to come, unless, perhaps, the usual slight decline which accompanies the months of July and August. Dealers specializing in woodworking machinery report that since the strike in the building trades, when trade dropped off, business has not regained its former good average.

Practically all dealers handling used machinery state that their sales for June are slightly in excess of those in May. The general feeling is one of hopeful expectancy that trade will show considerable improvement later on in the year.

Indianapolis

Some increase is to be noted in machinery and machine tool sales in this district during the last two weeks. The situation is not all it should be and conditions are spotty but the total sales volume is somewhat above the two weeks prior. All signs point to better business in late summer and early fall. As a general rule those factories which are the best buyers of machinery and tools are increasing their production and this means, eventually, an increase in tool and machinery business.

One of the bright spots is the sale of garage and automobile repair equipment. Sales of grinding machines, drills and similar equipment show a considerable gain with the coming of warm weather. This demand sould continue until cold weather. Sales of construction machinery, particularly for buildings, are just about holding their own. Sales of road equipment, both for construction, repair and upkeep are good and likely will remain good during July and August.

A good demand for special machinery for lumber mills continues to feature the local market. Sales of similar equipment to the furniture factories, however, are below the same time last year.

The four largest automobile plants in the state—Chrysler, Studebaker, Stutz and Marmon—continue to buy tools and their factories are working steadily.

What the Railroads Are Doing

There were 1,191 steam locomotives, valued at $42,241,284, produced in the United States by principal makers during 1925, according to data collected by the Department of Commerce. Other products of engine producers, including repair work, were valued at $23,147,850, making a total business of $65,389,134. Value of products of the industry last year was smaller than in any previous census year since 1914, when it was reported as $43,374,141.

The North American Car Co. has ordered 300 tank cars from the Bethlehem Steel Corporation and the Seaboard Air Line booked 20 steel passenger cars with the American Car and Foundry Co. and seven dining cars with the Pullman Car and Manufacturing Co.

In addition to purchase of 20 locomotives contemplated by the New York Central, previously reported, Jacksonville Terminal and Seaboard Air Line are both contemplating the purchase of a number of engines.

The Union Switch and Signal Co. has received orders for automatic signal apparatus covering 34 miles of single track for the Atlantic Coast Line.

One of the important lines of the Cologne-Bonn Railway Co., between Cologne and Bonn, which serves the centers of the Rhenish lignite industry as well as the principal agricultural centers of the Cologne district has been motorized, according to a consular report to the Department of Commerce. The company operating the line is owned by the municipal governments of Cologne and Bonn.

The Pennsylvania Railroad is in the market for about 30,000 tons of steel products for third-quarter deliveries. Bids have been asked on about 15,000 tons of plates, 6,000 tons of bars, 1,000 tons of shapes, and sizable lots of sheets, wire, axles, spikes, bolts and bars.

The Baldwin Locomotive Works has booked ten Santa Fe and 15 Mikado type engines for the Atchison, Topeka & Santa Fe and two switches for the Newburgh & South Shore.

The Canadian National ordered 30 dump cars from the National Steel Car Corporation, while the Southern Pacific booked 11 dining cars with the Pullman Car & Manufacturing Co.

The Chicago, St. Paul, Minneapolis & Omaha is inquiring for eight Mikado type locomotives, Erie wants 15 passenger cars and U. S. Cast Iron Pipe and Foundry Co. is in the market for six to ten gondolas.

The Reading Co. is asking bids on three combination passenger, baggage and mail gas-electric railway motor cars and one passenger trailer car.

Indianapolis properties of the Pennsylvania R.R. were inspected on June 16 by a party of the road's officials, including William W. Atterbury, president and general manager; Elisha Lee, vice-president, in charge of operations; C. M. Clement, assistant to Mr. Lee; Julius Eismann, vice-president in charge of traffic; J. E. Weller, traffic manager of the Western region; T. B. Hamilton, vice-president and general manager of the Western region, and Arthur Trimble, assistant to the chief engineer; W. C. Downing, general agent and superintendent in Indianapolis, accompanied the party.

Twenty Million for New Delco-Light Factory

A comprehensive program of factory expansion and building improvement, involving an expenditure of $20,000,000, was announced last week by the Delco-Light Co., at Moraine City, just south of Dayton. As a subsidiary of the General Motors Corporation, that organization is backing the vast industrial extensions planned by the Dayton concern, which manufactures Frigidaire products and lighting plants.

With the completion of the building-program early in 1927, the Delco-Light will give employment to more than 12,000 persons.

Through the installation of machinery costing $7,000,000 the company will be in a position to produce four electric refrigerators a minute, or 600,000 a year.

No change in the operation of the Taylor street plant in the heart of Dayton's industrial section is contemplated, nor will there be a transfer of the general offices from the Third National Bank Building, in which five floors are occupied by the executives and the cashier's offices.

The Frigidaire factory will be one mile in length. Thirty-six acres of floor space will be added to the plant.

G. A. Bauer Died Last Week

George A. Bauer, vice-president of the W. E. Shipley Machinery Co., of Philadelphia, died at his home in that city last week. He was 55 years old.

Mr. Bauer was born at Hamburg, N. Y., and as a youth showed a natural liking for things mechanical. As a young man he became associated with the E. A. Kinsey Co., of Cincinnati. After serving several years with this firm he went with the Harris Automatic Press Co., of Cleveland, but after a short time joined the Shipley organization. He had been associated with Shipley for twenty-five years. He was elected vice-president in 1908.

Mr. Bauer was perhaps one of the best known machinery men in the industry. He was known and liked by both executives and shop men, with whom he maintained a personal contact all through his business career. He numbered among his friends not only those immediate acquaintances in the field, but also many with whom he had only infrequent business association. His passing means a great loss to the machinery industry and to this host of friends.

Mr. Bauer's son, G. Frederick Bauer, is asociated with the Shipley company.

George A. Bauer

News of the Automotive Industry

Indications are that motor output in June will be materially lower than the output of recent months, as several large producers are closing their plants for inventory taking purposes and in preparation for new models to be introduced this summer. Other factories are understood to be working on schedules of four days a week for similar purposes.

Although May figures on production have not been issued, this procedure was apparent in the falling off in production last month, as trade estimates place total output at around 400,000 cars and trucks against over 450,000 in April. While some plants are shutting down for two or three weeks, the effect on total production for the month will probably not be as great as the length of the shut-downs indicates, as other plants are still working at high levels and still others have been stepping up their output in order to keep stocks normal following the heavy retail buying during May.

The Hupp Motor Car Corporation probably will break all records for production, sales and earnings in the current quarter.

The new $5,000,000 Pontiac plant to be completed Jan. 1, 1927, will add 1,440,000 sq.ft. of manufacturing floor space, increasing production capacity of the Oakland to approximately 400,000 cars a year. During past year over $3,500,000 has been invested in Oakland factories. Newly announced expansion brings added investment in little more than a year to nearly $9,000,000 and total investment of Oakland Motor Car Co., including inventories, to $50,000,000.

For the first time sales of Chevrolet Motor Co. in May exceeded April. During May, Chevrolet sold 70,935 cars in the United States an increase of 23,650 over May, 1925, when 47,285 cars were sold in domestic markets. Including Canada and overseas, the total sales were 84,944 cars.

For the first five months of 1926 the company sold 250,927 cars in the United States an increase of 84,138 over the same period of 1925.

The sale of American automobiles in Spain probably will be materially reduced if plans now under way are carried out.

The Spanish balance of trade has been seriously affected by the importation of automobiles, accessories and gasoline. A large part of this business is done by American firms. Under the leadership of Primo de Rivera the government is planning an important curtailment of importation. A thousand representatives of the Spanish automobile industry met with the Premier recently and discussed plans for the development of Spanish automobile factories.

Dodge Brothers business continues at the highest level in the company's history, with current output of between 35,000 and 40,000 vehicles monthly. For the first five months of the year the company's sales were 50 per cent ahead of 1925, the previous best year. Current daily output continues at the peak, averaging around 1,650 vehicles a day.

A contract for 100 three-purpose Navy planes has been let by the Government to the Glenn Martin Co. of Cleveland, Ohio, which submitted the lowest bid in the tenders received several days ago. The total made available for the planes was $4,100,000. Four other companies submitted bids.

The contract contemplates delivery within 16 months, 50 of the planes to be delivered at Hampton Roads and the other 50 at the company's Cleveland factory. The total cost will be $2,112,000, or approximately one-half of the available appropriation.

The Ford Motor Co. of Canada has reduced prices on all models $40 to $65, thus maintaining the customary differential between Canadian and American Ford prices. As in this country, balloon tires have been made standard equipment on all passenger cars, and starter standard equipment on touring and runabouts.

An amendment to the special war revenue act, presented to the House of Commons on June 7 by the Minister of Finance, proposes the removal of the excise tax of 5 per cent on passenger automobiles valued at not more than $1,200 coming from countries enjoying tariff concessions in Canada, states a report to the Department of Commerce.

It is a peculiar coincidence that at a time when the automobile engine of the future is receiving such careful study by engineers the world over, two of the models which are receiving attention have been developed in Montreal, Canada. One of them is the Caron engine, which is to be exploited in the United States by the duPont interests; the other is the Attendu engine, the development of which has been carried on by Montreal capital.

The entire development of these engines has been carried out in shops in Montreal and in the case of the Caron motor it is the invention of a French Canadian machinist, with the further assistance of the experimental work which was furnished by the Caron group.

Business Items

The H. A. Smith Machinery Co., of Syracuse, N. Y., is now representing the Cleveland Planer Co., of Cleveland, in the central New York territory.

The Crucible Steel Co. of America has leased property on Whitehall St., in the industrial section of Atlanta, and will establish warehouses and offices for a Southeastern distributing point.

Approximately 250 machine tools are being offered at a private sale by a representative of the Oliver Typewriter Co., of Woodstock, Ill. Bids are asked for the entire lot.

It is announced that the Brown, Boggs Co. of Hamilton, Canada, has, under the provisions of the Ontario Companies Act, changed its name to Brown Boggs Foundry and Machine Co.

The Wrightford Transmission Co., of Cincinnati, has been organized to manufacture a new hand gear shift for automobiles. George M. Morris and S. W. Blackburn are in charge of the organization.

The North & Judd Manufacturing Co., New Britain, Conn., recently acquired the August Buerman Co., of Newark, N. J. Like the North & Judd company the Buerman company manufactures bits and spurs, and has been in business many years.

The Chemical and Vacuum Machinery Co., Inc., of Buffalo, N. Y., has acquired all rights to build and market exclusively the Judelson Evapo-Dryer heretofore manufactured by the Judelson Evapo-Dryer Corporation, of New York.

W. A. Neal & Son, of Atlanta, distributors in the South of road building machinery and contractors' equipment, recently opened a new warehouse and general offices at Columbia, S. C., to handle the Carolina territory.

The Cooper Hewitt Electric Co., of Hoboken, N. J., announces plans for the expansion of its manufacturing facilities. A new building will be erected at Adams and Eighth Sts., to house several of the larger departments of the organization.

Construction of a new steel foundry near Winnipeg, Manitoba, to replace the structure destroyed by fire at Selkirk recently, has been announced by the Manitoba Steel Foundries. A concrete structure of the latest design for foundry practice will be erected.

Announcement is made by officials of the Cartersville Foundry and Machine Co., of Cartersville, Ga., of the purchase by the Guggenheim mining interests of considerable equipment for the company's tin mining operations in the Andes Mountains in South America.

Two Connecticut companies are included in the proposed merger of the New England Pin Co., of Winsted, the Star Pin Co., of Derby, and the National Pin Co., of Detroit, Mich. Tentative plans would combine the business of the New England company with the Star company and move all machinery to Derby.

The Kingsport Foundry and Machine Works, of Kingsport, Tenn., has started construction of three additional units including foundries and shops, it is announced by J. B. Burger, general manager. Some new equipment is to be installed in the shops, but most of the machinery will come from a plant recently acquired by the company at Marion, Va.

David A. Wright, Inc., an old established Chicago concern specializing in new and used machine tools, announces its retirement from business. The entire stock of tools and equipment will be sold at auction.

The Bertolette Machinery Exchange is now located in its new offices and warehouse in Jersey City, near the exit of the vehicular tunnel from New York. Mr. Bertolette Sr., formerly in charge of the New York Machinery Exchange, is head of the company. The offices are at 14th and Provost Sts., and it is announced that this company has no connection with others of a similar title.

Announcement is made to the trade of the consolidation of the Rockford Milling Machine Co. and the Rockford Tool Co., both of Rockford, Ill. The Rockford Tool Co. was organized in 1905 and with a small force began the production of engine lathes. A few years later the Sundstrand toolroom lathe was developed and the company expanded its operations. The Rockford Milling Machine Co. was organized in 1910 and its first production was confined to a limited selection of hand millers. Gradually the line was expanded until it now includes several well-known types of machines. Under the plan of consolidation the two engineering departments will be combined. The new name of the reorganized firm will be the Sundstrand Machine Tool Co. and the dictation of the company's polices will be in the hands of H. L. Olson, secretary and general manager. G. D. Sundstrand will continue as chief designer and inventor, assisted by C. A. Sundstrand.

Personals

JUSTUS H. SCHWACKE, formerly president and a director of William Sellers & Co., Inc., of Philadelphia, Pa., resigned and retired to private life on May 31. Mr. Schwacke had been with the Sellers company continuously since July 15, 1862. He was elected secretary when the company was incorporated in 1886, a director in 1902, manager in 1905, and president in 1922. He was active in the National Metal Trades Association, the National Founders Association and the Metal Manufacturers' Association, of Philadelphia, and has been a member of the Machinery Club of New York from its inception. Alexander Sellers was elected president on June 1 following the resignation of Mr. Schwacke. Mr. Sellers has been with the company since 1896, a director since 1902, and vice-president since 1905.

M. R. HART has been appointed manager of the Buffalo office of the Morse Chain Co., of Ithaca, N. Y.

HARRISON BROWNING has been appointed assistant engineer for the Machine Products Corporation, of Cleveland.

R. E. HOLBROOK, of Holbrook & Sons, Stratford, London, is in the United States on an extended business trip. He expects to visit several machine tool plants.

J. V. EMMONS has been elected vice-president of the Cleveland Engineering Society. He is metallurgist for the Cleveland Twist Drill Co.

CHARLES MODE, of Logansport, Ind., was re-elected regional chairman of the Western Region Shop Crafts Association of the Pennsylvania Railroad at the fifth annual meeting in Indianapolis. James White of Chicago was elected representative of the machinist craft.

PROFESSOR CHARLES W. LYTLE, director of industrial co-operation at New York University and chairman of the management section of the A.S.M.E., was elected secretary-treasurer of the Association of Co-operative Schools at the annual meeting of that body on June 15 at the University of Cincinnati.

JAMES F. TAYLOR, formerly president of the Algoma Steel Corporation, Ltd., Sault Ste. Marie, Ontario, who has been a member of the board of directors of the Sir W. G. Armstrong Whitworth & Co., Ltd., since June, 1925, is expected to take a prominent part in the reorganization of that company under Lord Southborough, who recently succeeded Sir Glyn West, as chairman of the board.

Obituaries

C. WALTER PANK, for many years vice-president of the Fairbanks-Morse Co., Chicago, died on Monday, June 21, in his 58th year. He retired from the company three years ago.

HENRY C. M. THOMPSON, former president of the American Hardware Corporation, of Hartford, Conn., died at his home in that city on June 18. He was 63 years old.

WILLIAM PETERS, retired manufacturer of machinery and machine tools, died at his home in Cincinnati on June 25. He was 69 years old. Mr. Peters was a partner in the firm of Peters & Bossert, and was also at one time an executive in the Cincinnati-Bickford Co.

VICTOR HUGO EMERSON, former president of the Emerson Phonograph Co., of New York, and widely known as an inventor of electrical apparatus, died at his home in Downey, Cal., on June 22. For many years Mr. Emerson has been associated with Thomas A. Edison in the perfecting of the phonograph.

ROGER W. DAVIS, for the past twenty-years a traveling salesman for the Saco-Lowell Shops, of Lowell, Mass., manufacturers of textile mill machinery, and for the last five years in charge of the Southern territory for that company, with headquarters at Charlotte, N. C., died suddenly at a private sanitarium in Atlanta recently following an illness of a few days.

Forthcoming Meetings

American Society of Mechanical Engineers. Spring meeting, Palace Hotel, San Francisco, Calif., June 28 to July 1. Chairman of convention, Warren H. McBride, the California and Hawaiian Sugar Refining Co., 215 Market St., San Francisco.

American Railway Tool Foremen's Association. Annual convention, Hotel Sherman, Chicago, Sept. 1, 2 and 3. G. G. Macina, secretary, 11402 Calumet Ave., Chicago.

American Railway Tool Foremen's Supply Association. Annual exhibit in connection with the annual convention of the American Railway Tool Foremen's Association, Chicago, Sept. 1, 2 and 3.

Machine Tool Exhibit. Sixth annual exhibition of machine tools at the Mason Laboratory, Yale University, under the auspices of the New Haven Section, A.S.M.E., the mechanical engineering department of the Sheffield Scientific School, and the New Haven Chamber of Commerce, Sept. 7 to 10. Administrative office, New Haven Machine Tool Exhibit, 400 Temple St., New Haven, Conn.

American Society for Steel Treating. Eighth national steel and machine tool exposition, Municipal Pier, Chicago, Sept. 20 to 24. W. H. Eisenman, secretary, 4600 Prospect Ave., Cleveland, Ohio.

Society of Automotive Engineers. Annual production meeting, Hotel Sherman, Chicago, Sept. 21, 22 and 23. John Warner, manager of meetings department, 29 West 39th St., New York.

American Foundrymen's Association. Second international foundrymen's congress, Detroit, Sept. 27 to Oct. 1, under the auspices of the American Foundrymen's Association. R. E. Kennedy, secretary, 909 W. California St., Urbana, Ill.

National Association of Manufacturers. Thirty-second annual meeting, Waldorf-Astoria Hotel, New York, Oct. 5, 6 and 7. George S. Boudinot, secretary, 50 Church St., New York.

National Safety Council. Fifteenth annual safety congress, Detroit, Mich., Oct. 25 to 29. A. A. Mowbray, director, 108 East Ohio St., Chicago.

The Weekly Price Guide

Rise and Fall of the Market

IN CONTRAST with the present quietness in the pig-iron market, steel buying is more active than it was a month ago. Structurals and wire products are the most promising on the list; bar demand is a trifle slower, following the recent spurt. The steel market is usually slower at this time of the year. Quotations on the principal hot-rolled products, in carload lots or over, are as follows: bars and shapes, $2 per 100 lb. with $1.90 mentioned on exceptional tonnages; plates, $1.85@$1.90 f.o.b. Pittsburgh mill. Non-ferrous metals and scrap show rising price tendencies. Most of the non-metallic materials and supplies remain fairly steady.

(All prices as of June 25)

IRON AND STEEL

PIG IRON—Per gross ton, f.o.b.:

CINCINNATI	
No. 2 Southern	$24.05
Northern Basic	24.27
Southern Ohio No. 2	23.27
NEW YORK—Tidewater Delivery	
Southern No. 2 (silicon 2.25@2.75)	27.37
BIRMINGHAM	
No. 2 Foundry	21.00
PHILADELPHIA	
Eastern Pa., No. 2x (silicon 2.25@2.75)	23.26
Virginia No. 2	28.67
Basic	22.26
CHICAGO	
No. 2 Foundry local	22.50
No. 2 Foundry, Southern (silicon 2.25@2.75)	25.05
PITTSBURGH, including freight charge ($1.76) from Valley	
No. 2 Foundry	20.27
Basic	20.27
Bessemer	20.27

IRON MACHINERY CASTINGS—Cost in cents per lb. of 100 flywheels, 6-in. face x 24-in. dia., hub not cored, good quality gray iron, weight 275 lb.:

Detroit	5.00@5.25
Cleveland	5.00@5.25
Cincinnati	5.00@5.50
New York	5.25@5.50
Chicago	5.25@5.75

SHEETS—Quotations are in cents per pound in various cities from warehouse; also the mill base in large lots.

Blue Annealed	Pittsburgh Mill Base	New York	Cleveland	Chicago
No. 10	2.30@2.40	3.89	3.15	3.50
No. 12	2.35@2.45	3.94	3.20	3.55
No. 14	2.40@2.50	3.99	3.25	3.60
No 16	2.50@2.60	4.09	3.35	3.70
Black				
Nos. 18 to 20	2.95@3.05	4.30	3.65	3.90
Nos. 22 to 24	3.00@3.10	4.35	3.70	3.95
Nos. 26 and 27	3.05@3.15	4.40	3.75	4.00
No. 28	3.15@3.25	4.50	3.85	4.10
Galvanized				
No. 10	3.25@3.40	4.65	4.00	4.25
Nos. 12 to 14	3.35@3.50	4.75	4.10	4.35
No. 16	3.50@3.65	4.90	4.25	4.50
Nos. 18 to 20	3.65@3.80	5.05	4.40	4.65
Nos. 22 to 24	3.80@3.95	5.20	4.55	4.80
Nos. 26 and 27	3.95@4.10	5.35	4.70	4.95
No. 28	4.25@4.40	5.65	5.00	5.25

WELDED STEEL PIPE—Warehouse discounts are as follows:

	New York Black	New York Galv.	Cleveland Black	Cleveland Galv.	Chicago Black	Chicago Galv.
1 to 3 in. steel butt welded	53%	39%	55½%	43½%	58%	45%
2½ to 6 in. steel lap welded	48%	35%	53½%	40½%	55%	42%

Malleable fittings: Classes B and C, banded, from New York stock sell at list plus 4% less 5%. Cast iron, standard sizes, 36-5% off.

Size, Inches	List Price per Foot	Diameter in Inches — External	Diameter in Inches — Internal	Thickness Inches
1	$0.17	1.315	1.049	.133
1¼	.23	1.66	1.38	.14
1½	.27½	1.9	1.61	.145
2	.37	2.375	2.067	.154
2½	.58½	2.875	2.469	.203
3	.76½	3.5	3.068	.216
3½	.92	4.0	3.548	.226
4	1.09	4.5	4.026	.237
4½	1.27	5.0	4.506	.247
5	1.48	5.563	5.047	.258
6	1.92	6.625	6.065	.28

SEAMLESS STEEL TUBING—Following net prices are for seamless mechanical tubing, cold drawn, round, .10 to .30 carbon, at warehouse in lots of less than 100 ft.:

Thickness — Decimal	B.W.G. and Fractions	Outside Diameter in Inches — ⅛	¼	⅜	½	1	1⅛	1¼
		Price per Foot						
.035"	20	$0.15	$0.16	$0.17	$0.18	$0.19	$0.21	$0.23
.049"	18	.17	.18	.19	.20	.21	.23	.25
.065"	16	.19	.20	.21	.22	.23	.25	.27
.083"	14	.20	.22	.23	.24	.25	.27	.29
.095"	13	.21	.23	.25	.26	.27	.29	.31
.109"	12	.22	.24	.26	.27	.28	.30	.32
.120" or .125"	11	.23	.25	.27	.28	.29	.31	.33
.134"	10	.24	.26	.28	.29	.30	.32	.34

MISCELLANEOUS—Warehouse prices in cents per pound in 100-lb. lots:

	New York	Cleveland	Chicago
Spring steel (light) (base)*	7.00	6.00@7.50	4.65†
Spring steel (heavier)	4.00	....	4.00
Coppered Bessemer rods (base)	6.05	6.00	6.20
Hoop steel	4.49	3.65	4.15
Cold rolled strip steel	6.25	6.35	6.25
Floor plates	5.25	5.30	5.00
Cold drawn shafting or screw	4.00	3.90	3.60
Cold drawn flats, squares	4.50	4.40	4.10
Structural shapes (base)	3.34	3.10	3.10
Soft steel bars (base)	3.24	3.00	3.00
Soft steel bar shapes (base)	3.24	3.00	3.00
Soft steel bands (base)	3.99	3.20	3.65
Tank plates (base)	3.34	3.20	3.10
Bar iron (3.00 at mill)	3.24	3.21	3.00
Drill rod (from list)	60@65%	55%	50%

Electric welding wire, New York, 3/32, 8.35c.; ⅛, 7.85c.; 5/32 to ½, 7.35c. per lb. *Flat, 1/16@¼-in. thick. †F.o.b. cars.

METALS

Current Prices in Cents Per Pound

Copper, electrolytic (up to carlots), New York			15.25
Tin, 5-ton lots, New York			63.87½
Lead (up to carlots) E. St. Louis	8.10	New York	8.87½
Zinc (up to carlots) E. St. Louis	7.17½	New York	8.12½

	New York	Cleveland	Chicago
Antimony (Chinese), ton spot	13.00	15.50	11.00
Copper sheets, base	22.50	22.50	22.50
Copper wire, base	19.25	16.50	16.00
Copper bars, base	22.12½	22.12½	21.87½@22.12½
Copper tubing, base	24.25	24.25	24.25
Brass sheets, base	18.87½	18.87½	18.87½
Brass tubing, base	23.50	23.50	23.50
Brass rods, base	16.62½	16.62½	16.62½
Brass wire, base	19.37½	19.37½	19.37½

Shop Materials and Supplies

METALS—Continued

	New York	Cleveland	Chicago
Aluminium ingots, 98 to 99%, 1 to 15 ton lots	27.00	27.00	27.02
Zinc sheets (casks)	12.75	12.55	11.51
Solder (½ and ½), (case lots)	39.12½	40.00	38½@42½

Babbitt metal, delivered, New York, cents per lb.:

Genuine, highest grade	76.37½
Commercial genuine, intermediate grade	54.50
Anti-friction metal, general service	30.50
No. 4 babbitt (f.o.b.)	13.87½

Nickel, f.o.b. refinery, cents per lb.: Ingots 31.00 Electrolytic 38.00 Shot 32.00

SPECIAL NICKEL AND ALLOYS—Price in cents per lb., f.o.b. Huntington, W. Va.:

Hot rolled nickel sheet (base)	52.00
Cold rolled nickel sheet (base)	60.00
Hot rolled rods, Grade "A" (base)	50.00
Cold drawn rods, Grade "A" (base)	58.00
Manganese nickel hot rolled rods "E"—low manganese (base)	54.00
Manganese nickel hot rolled rods "D"—high manganese (base)	57.00

Base price of Monel metal in cents per lb., f.o.b. Huntington, W. Va.:

Shot	32.00	Hot rolled rods (base)	40.00
Blocks	32.00	Cold drawn rods (base)	48.00
Ingots	38.00	Hot rolled sheets (base)	42.00
Cold rolled sheets (base)			50.00

OLD METALS—Dealers' purchasing prices in cents per pound:

	New York	Cleveland	Chicago
Crucible heavy copper	12.00 @12.25	11.25	11.25@11.75
Copper, heavy, and wire	11.25 @11.75	11.50	10.75@11.25
Copper, light, and bottoms	9.62½@10.12½	9.75	9.75@10.25
Heavy lead	7.25 @ 7.50	6.50	6.50@ 7.00
Tea lead	4.75 @ 5.25	5.00	5.50@ 6.00
Brass, heavy, yellow	7.00 @ 7.25	7.25	7.50@ 8.00
Brass, heavy, red	9.00 @ 9.50	9.50	8.75@ 9.25
Brass, light	5.75 @ 6.00	6.00	6.75@ 7.25
No. 1 yellow rod turnings	8.00 @ 8.50	8.00	7.75@ 8.25
Zinc	4.25 @ 4.75	4.00	4.25@ 4.75

TIN PLATES—American Charcoal—Bright—Per box

		New York	Cleveland	Chicago
"AAA" Grade: IC,	14x20	$12.10	$11.95	$11.50
"A" Grade: IC,	14x20	9.70	9.90	9.50
Coke Plates—Primes—Per box 100-lb.,	14x20	6.45	6.10	7.00
Terne Plates—Small lots, 8-lb. Coating—Per box IC,	14x20	7.75@8.00	6.95	7.50

MISCELLANEOUS

	New York	Cleveland	Chicago
Cotton waste, white, per lb.	$0.13@0.17½	$0.18	$0.15@0.20
Cotton waste, colored, per lb.	.10@ 14	.14	.12@.17
Wiping cloths, washed white, per lb	.18	36.00 per M	.16
Sal soda, per 100 lb. keg	2.05	2.25	2.75*
Roll sulphur, per 100 lb	3.60†	3.50	4.25‡
Linseed oil, per gal., 5 bbl. lots	.89½	.96	.94
Lard cutting oil, 25% lard, per gal.	.55	.50	.48
Machine lubricant, medium-bodied (55 gal. metal bbl.), per gal.	.35	.35	.29
Belting—Present discounts from list in fair quantities (½ doz. rolls).			
Leather—List price, 24c. per lin. ft. per inch of width for single ply.			
Medium grade	40–5%	40–5%	40–5%
Heavy grade	30–10%	30–10%	30–10%
Rubber transmission, 6-in., 6 ply, $1.83 per lin. ft.			
First grade	50%	50–10%	50%
Second grade	50–10%	60–5%	50–10%

*In 175 lb. kegs. † Per 150 lb. lot. ‡In 425 lb. barrels

Comparative Warehouse Prices

New York	Unit	Current Price	Four Weeks Ago	One Year Ago
Soft steel bars	per lb.	$0.0324	$0.0324	$0.0324
Cold drawn shafting	per lb.	.04	.04	.0415
Brass rods	per lb	.1662½	.1662½	.1587½
Solder (½ and ½)	per lb.	.3912½	385	.395
Cotton waste	per lb.	.13@.17½	13@.17½	15@22
Washers, cast iron (½ in.)	per 100 lb.	7.00	7.00	7.00
Emery disks, cloth, No. 1, 6 in. dia.	per 100	3.55	3.55	3.38
Lard cutting oil	per gal.	.55	.55	.55
Machine oil	per gal.	.35	.35	.35
Belting, leather, medium	off list	40–5%	40–5%	30–10%
Machine bolts, up to 1x30 in.	off list	40%	40%	40%

MISCELLANEOUS—Continued

	New York	Cleveland	Chicago
Abrasive materials—In sheets 9x11 in., No. 1 grade, per ream of 480 sheets:			
Flint paper	$5.56	$5.84	$5.65
Emery paper	10.71	11.00	10.71
Emery cloth	29.48	31.12	29.48
Emery disks, 6 in. dia., No. 1 grade, per 100:			
Paper	1.49	1.45	1.49
Cloth	3.55	3.55	3.20
Fire clay, per 100 lb. bag		.60	.75
Coke, prompt furnace, Connellsville	per net ton	2.75@ 3.00	
Coke, prompt foundry, Connellsville	per net ton	4.00@ 4.50	
White lead, dry or in oil	100 lb. kegs	New York, 15.25	
Red lead, dry	100 lb. kegs	New York, 15.25	
Red lead, in oil	100 lb. kegs	New York, 16.75	

SHOP SUPPLIES

Machine bolts, ¼x1½-in., per 100, $1.70. Discount at New York warehouses on all sizes up to 1x30-in., 40%; 1½ and 1¼x3-in. up to 12-in., 15%; with cold punched hex. nuts up to 1-in. dia. (plus std. extra of 10%) 30%; with hot pressed hex. nuts up to 1x30-in. (plus std. extra of 10%) 35%.

Carriage bolts, ¼x1½-in., per 100, $1.00. Discount on all sizes up to 1x30-in., 30%.

Coach and lag screws, 1½x$\frac{3}{16}$in., $2.25 per 100, less 40%.

Tap bolts, 1½x½-in., $1.00 per 100. List plus 35% at New York warehouses.

Bolt ends, 1x12-in., 10c. per lb., less 40%.

Nuts, semi-finished, ¼x½-in., 2c. each. Discount 70% for $\frac{3}{16}$-in and smaller and 65% for ¼-in. and larger.
Case hardened ¼x½-in., 6c. each, less 50%.

Rivets, button heads, ½-in., ⅝-in., 1-in. diam. x2$\frac{3}{16}$-in. to 4½-in. $5.00* per 100 lb. at New York warehouses; cone heads, same sizes, $5.20* per 100 lb. Rivets, $\frac{3}{16}$x1-in. and longer, 19c. per lb., less 50%. Same discount for tinned. EXTRA per 100 lb. for 1½ to 2-in. long, all dia meters, 25c.; ½-in. dia., 35c.; ½-in. dia., 75c.; 1-in. long and shorter, 75c.; longer than 5-in., 50c.; less than 200 lb. 50c.; countersunk heads, 45c.

Washers, cast iron, ½-in., $7.00* per 100 lb. at New York warehouses; ½-in., $6.00* per 100 lb.

*For immediate delivery from warehouse.

Machine Requirements and Industrial Construction

Machine Tools and Equipment Wanted

Calif., Alameda—W. G. Baden, secy. Bd. Educ., receives bids until July 6, equipment for high school shops, etc.

Calif., Benicia — Benicia Union High School Dist., H. B. Staley, Clk., receiving bids until July 6, machinery and tools for shop departments.

Mass., Boston—Forsyth Garage Corp., c/o S. S. Eisenberg, 46 Cornhill—miscellaneous tools and equipment for repair and service garage, Forsythe St. Estimated cost $150,000.

Mass., Boston—J. Magnes, 18 Tremont St.—miscellaneous tools and equipment for proposed garage and repair shop at Jamaica Plain. Estimated cost $100,000.

Mass., Boston—M. Rubin, 294 Washington St.—miscellaneous tools and equipment for proposed 1 and 2 story repair and service garage at Lexington. Estimated cost $160,000.

Mass., Boston—Schoolhouse Dept., City Hall—grinders, milling machines and metal working lathes.

Mass., Lynn—M. Galaid, 540 Beach St.—miscellaneous tools and equipment for repair and service garage, Chestnut St. Estimated cost $70,000.

N. J., Newark—Bd. of Education, P. O. Beebe, Dir., will receive bids until July 6 for machine and hand tools, auto mechanics equipment, electrical and carpentry department supplies, etc., for Essex County Vocational Schools.

N. S., Caledonia — Caledonia Pulp Mill, Ltd., c/o Scott Paper Co., Chester, Pa.—machinery and equipment for mill and machine shop.

Ont., Toronto—Bd. Educ., W. W. Pearce, 155 College St., receives bids until July 6, engine lathes, sheet metal machinery, grinders, machine shop equipment, etc., for technical schools. $25,000.

Opportunities for Future Business

Ala., Birmingham — The Birmingham Electric Co., J. S. Pevear, V. Pres. and Genl. Mgr., Empire Bldg., is having plans prepared for the construction of a 2 story, 120 x 150 ft. electric and gas distribution and storeroom building including installation department and repair shops at 6th Ave. and 12th St. Estimated cost $300,000.

Ala., East Gadsden (Gadsden P. O.)—Stringer Bros. Co., Inc., manufacturers of plumbing supplies, plans the construction of first unit to plant including foundry and machine shop. Three other units will be built later. Estimated cost $1,000,000.

Calif., Los Angeles—Los Angeles Railway Co., Railway Bldg., is receiving bids for the construction of a 1 and 2 story, 100 x 300 ft. auto repair shop on East 15th St. Private plans.

Calif., Richmond—Republic Steel Package Co., Chesley Ave., awarded contract for the construction of a 1 story, 82 x 200 ft. factory. $45,000.

Conn., Hartford—Hart & Hegeman Mfg. Co., 342 Capitol Ave., awarded contract for the construction of 1 additional story to 2 story plant for the manufacture of hardware.

Ill., Chicago—Chicago Pneumatic Tool Co., awarded contract for the construction of a 2 story, 50 x 60 ft. factory at Iron and W. 37th St. Noted June 10.

Ill., Chicago—Economy Pump Machinery Co., R. H. Thomas, Pres. and Treas., 1122 Curtis St., plans the construction of a 1 and 2 story factory. Architect not selected.

Ill., Chicago—Goodman Mfg. Co., C. H. Strawbridge, Pres., 4834 So. Halsted St., awarded contract for the construction of addition to warehouse, pattern shop and heat treating building. Estimated cost $125,000.

Ill., Niles Center—Chicago Rapid Transit Co., 72 West Adams St., Chicago, is having preliminary plans prepared for the construction of 1 story, 200 x 225 ft. repair shops, here. Estimated cost $350,000. A. Gerber, 72 West Adams St., Chicago, Archt.

Ind., Gary—Gary Heat, Light & Water Co., F. W. Van Sise, Supt., 5th St. and Broadway, awarded contract for the construction of a 3 story, 125 x 125 ft. garage and warehouse at 9th and Madison Sts. Estimated cost $200,000.

Ia., Ottumwa—John Morrell & Co., T. H. Foster, Pres., South Iowa St., is having sketches made for the construction of a machine shop. Henschein & McLaren, 1637 Prairie Ave., Chicago, Ill., Archts.

Md., Baltimore—Maryland Meter Works, Guilford and Saratoga Sts., manufacturers of water meters, will receive bids until July 6 for the construction of a 6 and 7 story, 110 x 164 ft. factory. Estimated cost $250,000. T. W. Pietsch, American Bldg., Archt. H. F. Doeleman, 507 North Charles St., Engr. Noted June 10.

Mass., Boston—Bd. of Street Commissioners, T. J. Hurley, Chn., City Hall, plans the construction of an underground garage under the Boston Common. Estimated cost $1,500,000. Architect not selected.

Mass., Boston—Dedham & Hyde Park Gas & Electric Co., B. J. Bean, Mgr., awarded contract for the construction of a 1 story repair and service garage. Estimated cost $40,000.

Mass., Brighton (Boston P. O.)—Mack Motor Truck Co., 75 North Beacon St., awarded contract for the construction of a 2 story garage. Estimated cost $160,000. Noted June 10.

Mass., Dorchester (Boston P. O.)—M. Galaid, 6 Walnut Ave., Revere, is having sketches made for the construction of a 1 story repair and service garage at Norfolk and Whitten Sts., here. Estimated cost $40,000.

Mass., Lynn—M. Galiad, 540 Beach St., Revere, will build a 1 story, 85 x 220 ft. repair and service garage at 234 Chestnut St. here. Estimated cost $70,000. E. Earp, 333 Union St., Lynn. Noted May 27.

Mass., Malden (Boston P. O.)—Malden Electric Co., 139 Pleasant St., will soon award contract for the construction of a 3 story, 122 x 185 ft. garage on Center St. Estimated cost $150,000. Charles H. Tenney & Co., 200 Devonshire St., Boston, Archt. and Engr.

N. Y., New York—Clyde Iron Works Sales Co., Locust Ave. and 136th St., awarded contract for the construction of a 1 story, 76 x 128 ft. factory. Estimated cost $65,000.

N. Y., Poughkeepsie—State Dept. of Public Works, A. W. Brandt, Comr. of Highways, Albany, will receive bids until July 8 for the construction of a 2 story, 68 x 188 ft. shop near here.

O., Cleveland—Acme Mfg. Co., H. Kronenberger, Pres., 2114 Woodland Ave., manufacturers of lighting fixtures, is having plans prepared for the construction of a 2 story, 54 x 170 ft. factory. Estimated cost $75,000. A. Sogg, 3030 Euclid Ave., Archt.

O., Cleveland—Columbian Vise & Mfg. Co., c/o Columbian Hardward Co., H. J. Seymour, Pres., 5113 Hamilton Ave., awarded contract for the construction of a 1 and 2 story, 75 x 160 ft. factory at 9021 Bessemer Ave. Estimated cost $75,000.

O., Cleveland—The Domestic Electric Co., C. A. Duffer, Pres., 7209 St. Clair Ave., awarded contract for the construction of a 1 story, 40 x 140 ft. addition to factory. Estimated cost $40,000.

O., Cleveland—W. S. Tyler Co., C. Zimmerman, Secy. and Treas., 3615 Superior Ave. (ornamental iron and bronze work) awarded contract for the construction of a 1 story, 43 x 59 ft. addition to annealing plant at 1370 East 36th St. Estimated cost $40,000. Noted Mar. 4.

O., Cleveland Heights (mail Warrensville)—P. Matzinger & Lehman Schmitt Co., Assoc. Archts., 1740 East 12th St., Cleveland, are receiving bids for the construction of a 1 story, 60 x 175 ft. garage on Mayfield Rd. for Louis Stone Estate.

O., Columbus—Bd. of Education, E. L. McCune, Clk., awarded contract for the construction of a 1 story, 65 x 150 ft. shop for Central High School on West Broad St. $61,975.

O., Mansfield—B. H. Prack, Martin Bldg., Pittsburgh, Pa., Engr., will build a 4 story addition to manufacturing plant here for Westinghouse Electric & Mfg. Co., East Pittsburgh, Pa. Estimated cost $450,000.

Pa., Philadelphia—Abrasive Co., Tacony and Fraley Sts., manufacturers of grinding tools, will build a 2 story addition to factory. Estimated cost $20,000. Private plans.

Pa., Philadelphia—J. Brady, c/o Commercial Casualty Insurance Co., Inc., 136 South 4th St., is having plans prepared for the construction of a 5 story, 98 x 100 ft. garage at 924 Spring St. Estimated cost $175,000. I. T. Chatarine, 812 Franklin Trust Bldg., Archt.

Pa., Philadelphia—Samuel Frank Stanley Coal Co., 136 Washington Ave., is having plans prepared for the construction of a 65 x 115 ft. garage at W. S. 16th, Spruce and Pine Sts. Estimated cost $150,000. I. W. Levin, 1011 Chestnut St., Archt.

Pa., Philadelphia—Soabar Co., 4608 Edmund St., manufacturers of price marking equipment, awarded contract for the construction of a 1 story, 107 x 110 ft. factory at Erdrick and Vankirk Sts. Estimated cost $40,000. Noted May 20.

Tenn., Chattanooga — Southern Railway 1300 Penn Ave., Washington, D. C., awarded contract for the design and construction of a locomotive terminal including roundhouse, machine shop, smith and tank shop, power house, etc. here to Dwight P. Robinson & Co. Inc., 125 East 46th St., New York, N. Y. B. Herman, Washington, D. C., Ch. Engr.

Va., Covington—Bates Valve Bag Co., 8240 South Chicago St., Chicago, Ill., awarded contract for the construction of a 1 story, 80 x 240 ft. manufacturing plant here.

Va., Richmond—Richmond Motor Terminals, R. T. Lipscombe, Fiscal Agt., Tenth and Broad Sts., will build an 8 story garage at Tenth and Bank Sts. Estimated cost $850,000.

Wis., Milwaukee—Cyra's Battery & Ignition Co., F. & H. Cyra, 715 Forest Home, will have revised plans prepared for the construction of a 1 story, 30 x 48 ft. shop. Gurda & Gurda, 448 Mitchell St., Archts. Former bids rejected.

Wis., Milwaukee — Mack International Motor Truck Co., 132 East 23rd St., Chicago, Ill., awarded contract for the construction of the first unit to repair and service garage, 1 story, 200 x 212 ft. at Highbury Pl., here. Estimated cost $100,000.

Wis., Two Rivers—Hamilton Mfg. Co., manufacturers of steel printers' cabinets, etc., awarded contract for the construction of a 1 story, 65 x 125 ft. and 3 story, 70 x 150 ft. additions to plant. Estimated cost $70,000. Noted June 24.